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An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Full Page Advertisement, May 28.

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7941
See half-page Advertisement page 91, May 14.

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Engineering Special Classes. Marine & Aero-Engines, Alternating Currents, Wireless Course, Ferro-Concrete, Refrigeration, Pract. Maths. and Calculus.—PENNINGTONS, University Tutors, 264, Oxford Rd., Manchester.

TENDERS.

LONDON COUNTY COUNCIL.

Tenders are Invited for

Repairs to the pavements of Blackwall and Rotherhithe Tunnels.

Persons desiring to tender may obtain the specifications, bills of quantities, form of tender, drawings, etc., on application to The Chief Engineer at the County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £3. This amount will be returnable only if the Tenderer shall have sent in a bona fide Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawings, specifications, and other contract documents may be inspected at the County Hall before the payment of the fee. No Tender received after 4 p.m. on Monday, 21st June, 1920, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.
G 876

IPSWICH CORPORATION WATERWORKS.

TO DIESEL OR SEMI-DIESEL OIL ENGINE MANUFACTURERS.

TENDERS FOR THE MANUFACTURE AND ERECTION OF ENGINE AND PUMPING MACHINERY.

The Ipswich Corporation invite

Tenders for the Supply and ERECTION of ONE OIL ENGINE, together with vertical shaft driven high-lift centrifugal Pump capable of raising three million gallons per 24 hours.

Forms of Tender, conditions of contract, specification and other necessary particulars may be obtained from the undersigned on receipt of One Guinea, returnable on condition that a *bona-fide* Tender is sent in.

Tenders, enclosed in sealed envelopes, addressed to the Town Clerk, Ipswich, and endorsed "Tenders for Pumping Machinery," must be delivered at the Town Clerk's Office, Ipswich, not later than 12 o'clock noon on the 22nd July.

C. W. S. OLDHAM,
Water Engineer,
Ipswich Corporation.
June, 1920. G 838

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD.
(PLANT AND MACHINERY SECTION.)

For Sale by Public Tender,

ADMIRALTY OIL FUEL INSTALLATION.

Erected at SOUTH QUAY, SOUTH HARBOUR, BLYTH (Northumberland), consisting of FOUR STEEL OIL TANKS, each 30 feet long by 9 feet diameter with length of 7 in. W.I. Pipe line. Purchasers will require to remove the installation from present site.

Drawings can be seen, permits to view and Tender Forms obtained from the Controller, Plant and Machinery Section, Disposal Board, D.B.I.E., Charing Cross Embankment Buildings, London, W.C. 2.

Tenders close on 11th June.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 3s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. G 826

AUCKLAND HARBOUR BOARD. NEW ZEALAND.

Tenders are Invited for the SUPPLY of ONE Two Ton TRUCK CRANE. Specifications can be obtained on payment of a deposit of Two Guineas, at the office of the Board's Agents, Messrs. W. & A. MCARTHUR, LTD., 18/19, Silk Street, Cripplegate, London, E.C. 2.

Tenders to reach Messrs. W. & A. MCARTHUR, LTD., not later than 31st July, 1920. G 775

LONDON COUNTY COUNCIL.

Tenders are Invited for the Repaving of the Carriageway of Albert Suspension Bridge.

Persons desiring to tender may obtain the specification, bills of quantities, form of tender, etc., on application to the Chief Engineer, at the County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £3. This amount will be returnable only if the Tenderer shall have sent in a bona fide Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the specification and other contract documents may be inspected at the County Hall before the payment of the fee. No Tender received after 4 p.m. on Monday, 21st June, 1920, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.
G 877

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD
(PLANT AND MACHINERY SECTION).

FOR SALE BY PUBLIC TENDER
OIL FUEL INSTALLATION.

Tenders are Invited for the following:—

ADMIRALTY OIL FUEL INSTALLATION, erected in 1916, on land adjacent to Alexandra Dock, Hull, known as Hedon Road Reservation, consisting of STEEL TANK, 30 ft. dia. by 30 ft. deep, with C.-I. pipe lines, from 5 in. to 15 in. dia., running under or along the adjacent land and jetty. The PUMP HOUSE 31 ft. 6 in. by 23 ft. 6 in. contains 2 Hayward Tyler Pumps, each direct coupled to motor.

The Hull Corporation are prepared to negotiate with a reputable purchaser for a lease of the land on which part of this installation stands (including Tank and Pump House) for a term of 50 years with option of renewal for a further 25 years, but the pipe lines which run along jetty will require to be removed.

Drawings and Specifications can be seen, permits to view and Tender Forms obtained from the CONTROLLER, Plant and Machinery Section of Disposal Board (D.B.I.e.), Charing Cross Embankment Buildings, London, W.C. 2.

Tenders close on June 14th, 1920.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. G 760

APPOINTMENTS OPEN.

Woolwich Polytechnic — DEPARTMENT OF MATHEMATICS.—LECTURER REQUIRED to take classes in Mathematics for Engineering students, and in Pure and Applied Mathematics, up to Final B.Sc. standard of London University. Commencing salary up to £315, according to previous experience, with increments according to L.C.C. scale. Duties to commence in September. Apply PRINCIPAL. G 881

Woolwich Polytechnic — DEPARTMENT OF ENGINEERING.—ASSISTANT LECTURERS REQUIRED for Mechanical or Electrical Engineering. Degree or equivalent qualification essential. Commencing salary up to £275 or £315 per annum, according to previous experience, with increments according to L.C.C. scale. Duties to commence in September. Apply PRINCIPAL. G 882

LANCASTER EDUCATION COMMITTEE.

JUNIOR TECHNICAL SCHOOL.
STORRY INSTITUTE.

Wanted, Assistant Master, to take Junior Technical School Drawing and Metalwork. Salary according to the Lancashire County Council Scale, namely, Graduates £300, rising to £450; Non-Graduates £160, rising to £380. Forms of application and particulars may be obtained on receipt of a stamped addressed envelope from GEO. H. MITCHELL, Secretary for Education, Town Hall, Lancaster.

28th May, 1920. G 818

UNIVERSITY OF MANCHESTER.

The Council is about to make

Two Appointments in the DEPARTMENT of ENGINEERING. Each post will be that of Assistant Lecturer and Demonstrator in Drawing.

The appointments are for three years, and the duties commence in October next.

Applications should be sent, not later than 21st June, to the SECRETARY to the Senate, from whom further particulars may be obtained. G 738

UNIVERSITY COLLEGE, NOTTINGHAM.

DEPARTMENT OF ENGINEERING.

Junior Lecturer in Mechanical Engineering. WANTED, to commence duties as early as possible. Commencing salary £300 per annum.

Further particulars and application forms may be obtained from the REGISTRAR, to whom they should be returned not later than June 21st. G 914

HARRIS INSTITUTE, PRESTON.

Wanted a full time Assistant TEACHER in Mechanical Engineering to commence duties in September. Applications before 16th June stating age, qualifications, and teaching experience with salary required to the Principal. G 691

NATIONAL FEDERATION OF PROFESSIONAL, TECHNICAL, ADMINISTRATIVE, AND SUPERVISORY WORKERS.

A Full Time General SECRETARY is REQUIRED for the above Federation. Commencing salary £450 per annum. Applications to be received, stating full qualifications (Society, previous experience, age, &c.) not later than 19th June, and to be addressed to the NATIONAL FEDERATION at 34, Eccleston Square, Westminster, S.W. 1. G 901

ASSISTANT MASTER, H.M. DOCKYARD SCHOOLS.

Applications are Invited for the POST of JUNIOR ASSISTANT MASTER in the above schools.

Candidates should possess a University Degree in Honours in Science or Engineering, or have equivalent qualifications, and should produce evidence of successful teaching and experience in laboratory work. They must be medically fit.

The subjects taught in the schools are Mathematics, Applied Mechanics, Magnetism and Electricity, Heat, Steam, Metallurgy, Mechanical Drawing and English.

Salary scale £180—£10—£240—£15—£450.

There is a War Bonus varying from £153 17s. 6d. for the minimum point on the scale up to £251 7s. 6d. for the maximum.

The selected candidate will be required to commence his duties about 1st August next.

Applications should be addressed to THE SECRETARY OF THE ADMIRALTY (C.B.), Whitehall, London, S.W. 1. G 757

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. SCHOFIELD, M.B.E., B.Sc., A.R.C.Sc.; A.M.I.C.E., D.I.C., Principal.

The Governors of the College invite

Applications for the following VACANCIES:—

Two LECTURERS in the Department of Mechanical Engineering, one to specialise in Machine Drawing and Design. Candidates must be graduates of a University in the United Kingdom, and previous teaching experience is desirable. The commencing salary for each appointment is at the rate of from £350 to £400 per annum, according to experience and qualifications.

Applications must be made on the prescribed form, which may be obtained from the PRINCIPAL of the College, to whom they must be returned not later than Thursday, the 17th June, 1920.

Correspondents should refer to the particular vacancy for which they desire to offer themselves as candidates.

26th May, 1920. G 826

GLAMORGAN EDUCATION COMMITTEE.

APPOINTMENTS OF LECTURERS IN MECHANICAL AND ELECTRICAL ENGINEERING.

The Committee propose to

Appoint Two Travelling LECTURERS in mechanical and electrical engineering respectively. Applicants must possess special qualifications for teaching engineering and allied subjects. Successful candidates must devote their whole time to the duties and reside where directed by the Committee, and will be required to commence duties in September next.

Salary £250 per annum, rising by annual increments of £15 to a maximum of £450 with expenses according to scale. Regard may be had to previous full-time teaching experience in a recognised efficient school in assessing the commencing salary, subject in the case of service under other Authorities to a limit of 10 years. Canvassing will disqualify.

Applications, on forms which will be supplied on receipt of a stamped addressed foolscap envelope, must reach the CHIEF EDUCATION OFFICIAL, County Hall, Cardiff, by the 18th June, 1920. G 742

DARLINGTON EDUCATION COMMITTEE.

TECHNICAL COLLEGE.
Principal—R. M. CAVEN, D.Sc.

Applications are Invited for the following POSTS:—

(a) HEAD OF THE DEPARTMENT OF ELECTRICAL ENGINEERING, PHYSICS and PURE MATHEMATICS. Commencing Salary £350 per annum, rising by annual increments of £12 10s. to £400. Applicants are required to be Graduates of British Universities.

(b) ASSISTANT LECTURER IN ENGINEERING. Commencing salary £300, rising by annual increments of £12 10s. to £350. Preference will be given to Graduates of British Universities with Practical Engineering experience.

Further particulars and Forms of Application may be obtained from the undersigned, to whom completed Forms should be returned not later than the 12th June, 1920.—A. C. BOYDE, Director of Education and Secretary.—May, 1920. G 703

KENT EDUCATION COMMITTEE.

BRITH TECHNICAL INSTITUTE.

A Graduate is Required to teach Mathematics and be responsible for the organisation of the subject in the Day and Evening Engineering School.

Salary in accordance with the Scale of the Kent Education Committee; to a suitable man with necessary experience, an initial salary of £350 might be paid.

Further particulars and forms of application may be obtained from The Secretary, Mr. ARTHUR T. FLUX, Education Office, Belvedere.

Application, stating full name, age, qualifications and experience, together with copies of three recent testimonials, should be sent at once to Mr. W. NEAGLE, Technical Institute, Belvedere.

E. SALTER DAVIES,
Director of Education.
28th May, 1920. G 909

University of Bristol. ASSISTANT LECTURER IN ENGINEERING, £300—£10—£380.

For particulars and form of application send at once stamped, addressed, foolscap envelope to the REGISTRAR of the Merchant Venturers' Technical College. G 824

ST. HELENS EDUCATION COMMITTEE.

THE MUNICIPAL TECHNICAL SCHOOL.

Wanted for September, the following TEACHERS:—

1. Head of Mining Department.
2. Head of Engineering Department.

Salary in each case £375 per annum, rising by annual increments of £15 to £450 per annum.

Forms of application may be obtained by sending stamped addressed foolscap envelope to the undersigned, and should be returned as early as possible.

Education Office, St. Helens. JOHN A. HARTLEY, 2nd June, 1920. Secretary for Education. G 941

Wanted, Rate-Fixer, for Modern Engineering Works. Applicants must have had similar experience and be conversant with the latest tools and methods, and able to demonstrate.—Address, giving full particulars, salary required, and when at liberty. G 819, Offices of ENGINEERING.

Wanted, Smart and Energetic MAN, for an up-to-date Tool Room in a large Commercial Motor Manufacturers, in the North. Must be well up in Gauge and Jig Manufacture. Permanent position for the right man.—Address, stating experience and salary required, to F 716, Offices of ENGINEERING.

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Estimator, Junior, Required for Birmingham district to assist in calculating weights of drop forgings and castings from working drawings. Permanency to right man.—Address, stating in confidence age, experience, salary required, &c., G 903, Offices of ENGINEERING.

Estimator Required for Birmingham district, experienced in reading working drawings, and calculating weights of drop forgings and castings from same. Knowledge of costing an advantage though not essential. Apply stating in confidence age, experience, salary required, &c. Permanent progressive job for right man.—Address G 904, Offices of ENGINEERING.

Estimating Expert, thoroughly experienced and of proved ability, REQUIRED by firm of Ship and Engine Repairers. Only those need apply who have been trained in this branch of business, and have a thorough knowledge of labour and material values, and are qualified to prepare reliable working estimates for repairs and renewals to the hulls and machinery of all types of vessels. Drawing Office experience a recommendation.—Write, stating age, experience and salary required, Z. J., 190, care DEACONS, Leadenhall St., London. G 892

Assistant, with First-class Engineering, and/or Metallurgical training REQUIRED in London and Provinces. Good prospects for young man of capacity and initiative. State qualifications, experience and remuneration expected.—BOX 994, POTTER'S Advertising Agency, Imperial House, Kingsway, London, W.C. 2. G 893

Clerk of Works Wanted immediately to superintend erection and lay-out, new engineering shop; premises, plant and sidings, check quantities and accounts; practical knowledge all trades; good salary paid to thoroughly competent experienced man. Three months' job, commence immediately.—Address, G 905 Offices of ENGINEERING.

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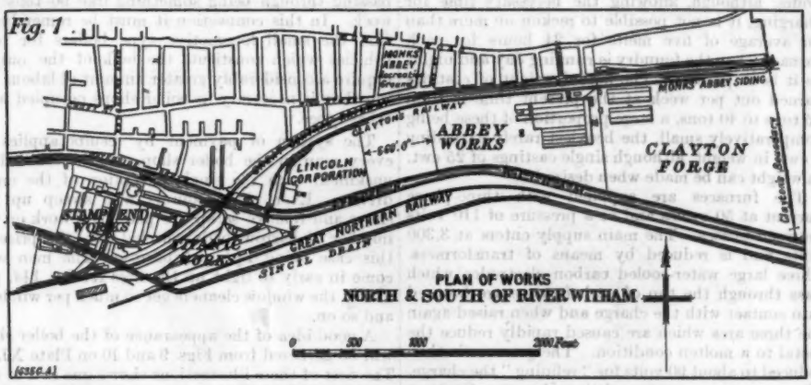
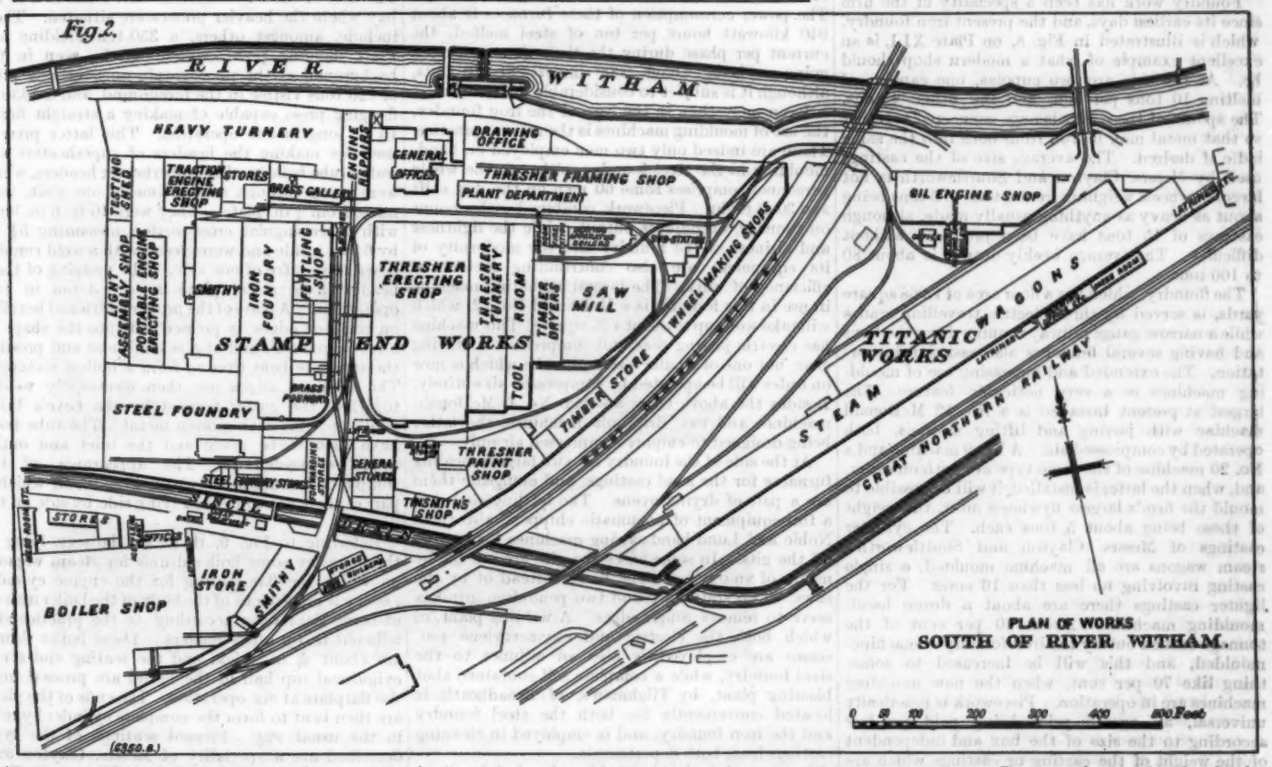
THE WORKS OF MESSRS. CLAYTON AND SHUTTLEWORTH, LTD., AT LINCOLN.

THE present extensive works of Messrs Clayton and Shuttleworth, Limited, at Lincoln, had their origin, like so many other successful engineering enterprises, in very humble beginnings. In the year 1842 Mr. Nathaniel Clayton and Mr. Joseph Shuttleworth, one a skilled moulder and the other a clever mechanic, settled in Lincoln and entered into partnership to start a small engineering business. Their first workshop was situated on a small plot of land on the banks of the River Witham, and of the one and a half acres the site comprised half was covered with water during the greater part of the year. The business thus founded rapidly grew and prospered until at the present time the works of Messrs. Clayton and Shuttleworth, Limited, cover 100 acres and give employment to some 5,000 people, while the products of the firm are known in every quarter of the globe.*

Ironfounding was the early speciality of the original partners, and the first contract which really set the young enterprise firmly on its feet was for the iron pipes for the Minningsley-Boston water supply. The engineer for the work, the late Mr. Thomas Hawksley, was anxious to get pipes considerably thinner than most foundries were able to cast. The usual practice in those days was to cast the pipes horizontally, but Mr. Clayton realised that if they could be cast vertically a sounder and lighter product could be obtained. He made experiments to test this, and these were so successful that he was awarded the contract. The monetary resources of the partners were, however, insufficient to provide the financial guarantee required, but assistance in this respect was obtained from Mr. Seeley, of Lincoln, who had confidence in the young firm and remained for many years a sleeping partner in it.





It was about the middle of the last century that steam power was first applied to agricultural purposes, and Messrs. Clayton and Shuttleworth were amongst the earliest to realise its possibilities and to start the manufacture of machinery for farm uses. They made their first portable steam engine in the year 1845 and have since supplied over 120,000 thrashing sets for all parts of the world. The firm were also pioneers in the development of steam traction engines, while more recently light steam tractors, chain-track tractors, railway carriages and wagons, and heavy oil engines have all been produced on a very large scale. During the war many of the standard products of the works were urgently needed by the Government and the military authorities for haulage and transport work, but the manufacture of Handley Page aeroplanes, Sopwith triplanes, howitzer gun carriages, timber wagons and special tractors and rolling stock were also undertaken on a large scale. Altogether about 1,000 aeroplanes, 200 gun carriages and 1,000 tractors were supplied to the Government, in addition to numerous smaller contracts.

Messrs. Clayton and Shuttleworth, Limited, possess altogether three separate works in Lincoln: the Stamp End Works, the Titanic Works and the Abbey Works, employing altogether over 5,000 hands. All three are on the banks of the Witham at the eastern end of the city, the two former being almost adjoining each other on the south bank of the river and the Abbey Works, including the Clayton forge, about half a mile away on the other bank. We have already given an idea of the range of activity of the firm at the present time, and it is noticeable how far self-contained the company is with regard to the production of its own specialities. An exceptionally fine steel foundry makes it independent of other manufacturers in respect of steel castings, of which it can ensure its own requirements, both as regards delivery and quality, while it also supplies the outside market. It is in a similarly happy position with regard to drop stampings, of which, as well as of steel castings, Messrs. Clayton and Shuttleworth, Limited, are large consumers. Their new stamping works is one of the best equipped in Great Britain and this also has a capacity beyond the immediate requirements of the firm. Standardisation of product and mass production on modern lines are characteristic of the various departments, and especially so as regards the manufacture of steam wagons. Payment by results, in the form of a straight piecework system, is the rule throughout the works, some of the most unlikely operations being found amenable to this method of rewarding skill and energy.

A general plan of the various works of Messrs. Clayton and Shuttleworth is given in Fig. 1, annexed, which will enable their proportions and relative positions to be realised. They are well served by the Great Northern and Great Central Railway lines, and spur tracks enable material to be brought close to the point of the works for which it is destined. The despatch of finished goods by rail is equally easy, though of course a large proportion of Messrs. Clayton and Shuttleworth's manufactures, especially for this country, leaves by road and travels on its own wheels.

It should be mentioned that the Titanic Works

* It is now nearly fifty years since, in our issues of August 12, 19, and 26, pages 107, 127, and 146, we published an account of the Stamp End Works as they then existed.

and the Abbey works, including the Forge, have recently been taken over by a subsidiary company under the name of Clayton Wagons, Limited. The new company is of course very closely allied with the parent company and the personnel of these works is practically the same as before. Messrs. Clayton Wagons, Limited, will devote themselves exclusively to the manufacture of steam and electric road wagons in the Titanic Works and to railway rolling-stock, drop stampings and steel forgings in the Abbey Works.

The Stamp End Works.

The Stamp End Works, the oldest and largest of the three works of the firm, covers the site of the original workshop of Messrs. Clayton and Shuttleworth. It occupies about 25 acres, and gives employment to about 2,000 workpeople. A plan of the Stamp End Works is reproduced in Fig. 2, on page 741, and the names of the shops give a clue to the nature of the products of the works. Among the principal of these are steam tractors, trailer wagons, traction engines, road rollers, portable engines, heavy oil engines, oil-driven chain-track tractors, thrashing machines, chaff cutters, clover hullers, elevators, maize shellers, boilers and steel castings. Over 50,000 portable engines and approximately the same number of thrashing machines have been turned out of these works.

The Iron Foundry.

Foundry work has been a speciality of the firm since its earliest days, and the present iron foundry, which is illustrated in Fig. 8, on Plate XLI, is an excellent example of what a modern shop should be. At the side are two cupolas, one capable of melting 10 tons per hour and the other 4 tons. The spouts of these cupolas are connected together so that metal may be run from both into the same ladle if desired. The average size of the castings used by Messrs. Clayton and Shuttleworth is not large, flywheels weighing from 4 tons to 5 tons being about as heavy as anything usually made, although castings of 15 tons have been produced without difficulty. The average weekly output is about 80 to 100 tons.

The foundry, which has a floor area of 1,968 square yards, is served by three electric travelling cranes while a narrow-gauge railway running down the bays and having several branches also assists transportation. The extended and increasing use of moulding machines is a very noticable feature. The largest at present installed is a No. 12 McDonald machine with jarring and lifting motions, both operated by compressed air. A No. 9 machine and a No. 20 machine of the same type are both on order, and, when the latter is installed, it will be possible to mould the firm's largest flywheels on it, the weight of these being about 5 tons each. The cylinder castings of Messrs. Clayton and Shuttleworth's steam wagons are all machine moulded, a single casting involving no less than 16 cores. For the lighter castings there are about a dozen hand-moulding machines. About 40 per cent of the tonnage turned out by the iron foundry is machine-moulded, and this will be increased to something like 70 per cent. when the new moulding machines are in operation. Piecework is practically universal, an agreed price being paid per box according to the size of the box and independent of the weight of the casting or castings which are being moulded. Most of the machine moulding is done with wooden-patterns. These are made of hard wood and as they are free from the knocking about which falls to the lot of ordinary patterns their life is almost indefinite.

The Steel Foundry.

The manufacture of steel castings is a recent enterprise of Messrs. Clayton and Shuttleworth, Limited, having been undertaken since the war not only to provide for their own large requirements, but to supply the needs of the general market as well. The steel foundry, which is illustrated in Fig. 6 on Plate XL, is an excellently-lighted rectangular building, having a floor area of 3,359 square yards. It is well equipped for economical working and contains seven overhead travelling cranes, the largest, which is over the new casting bay, having a capacity of 25 tons. The others include five of 3-tons capacity and one of 5-tons capacity. The foundry is served with a standard gauge railway spur, so that heavy materials can be loaded direct into, and unloaded from trucks.

The steel is melted in a pair of Heroult electric furnaces, situate on a raised steel platform for convenience of working. These furnaces, each of which has a capacity of 30 cwt., can be seen in the illustration. They are charged with scrap steel and turnings, and a charge can be melted in four hours, although, allowing the necessary time for charging, it is not possible to reckon on more than an average of five melts for 24 hours for each furnace when the foundry is running day and night, as it is at present. The actual weight of castings turned out per week at the present time is from 35 tons to 40 tons, a large proportion of these being comparatively small, the heaviest rarely exceeding 8 cwt. in weight, although single castings of 25 cwt. in weight can be made when desired.

The furnaces are supplied with three-phase current at 50 cycles and at a pressure of 110 volts between phases. The main supply enters at 3,300 volts and is reduced by means of transformers. Three large water-cooled carbon electrodes which pass through the top of each furnace are lowered into contact with the charge and when raised again the three arcs which are caused rapidly reduce the metal to a molten condition. The pressure is then reduced to about 90 volts for "refining" the charge. The power consumption of these furnaces is about 940 kilowatt hours per ton of steel melted, the current per phase during the time that melting is going on being about 5000 amperes at 110 volts, although it is subject to considerable fluctuations.

Even more than in the case of the iron foundry, the use of moulding machines is the general practice. There are indeed only two men employed on hand-moulding in the steel foundry, although the whole personnel comprises some 60 men on the day shift and 30 at night. Piecework, combined with a bonus on tonnage, encourages output, while the lightness and airiness of the foundry and the modernity of its equipment are also contributing factors to efficiency of work. The largest moulding machine in use in this foundry is a McDonald No. 12, which will take work up to about 4 ft. square. This machine has electric jarring gear and compressed air lifting gear, but one of similar size and make which is now on order will be operated by compressed air entirely. Besides the above there are two No. 6 McDonald machines and two Britannia machines, the latter being designed to employ compressed air only.

At the side of the foundry are two large annealing furnaces for the steel castings, and alongside them are a pair of drying ovens. The fettling shop has a full equipment of pneumatic chippers, also three Noble and Lund band-sawing machines for cutting off the gits. In some cases the gits are cut off by means of an oxy-acetylene flame instead of by the saws. Two stationary and two pendulum grinders serve to remove rough edges. A welding plant, in which both the electric and oxy-acetylene processes are employed, is also an adjunct to the steel foundry, while a complete self-contained shot blasting plant, by Tilghman's, of Broadheath, is located conveniently for both the steel foundry and the iron foundry, and is employed in cleaning castings from both departments.

In connection with the steel foundry the laboratory should be mentioned, in which routine chemical tests and special analyses are made. Messrs. Clayton and Shuttleworth do not themselves manufacture any of the numerous alloy steels which are used for special purposes, but they keep a very careful check upon the composition of material supplied in order that they may guarantee the quality of the drop stampings and forgings which they largely manufacture from alloy steels.

The Boiler Shop.

The manufacture of boilers forms a considerable item in the activities of the Stamp End Works, for not only have the needs of the firm to be met in so far as the requirements of their portable engines, traction engines, steam wagons and road rollers are concerned, but the manufacture of watertube boilers and superheaters is also carried out at these works. Reference to Messrs. Clayton and Shuttleworth's water-tube boilers will be made later. The boiler-shop at present comprises five bays, and is about 280 ft. square, exclusive of the space occupied by stores. It gives employment to from 300 men to 350 men, although when the extensions which have been decided upon are carried out both the area and the personnel will be materially increased. The present output of the shop is about 20 boilers per week, exclusive of water tanks for steam wagons and other sundries, the total weight of material passing through being something like 90 tons per week. In this connection it must be remembered that the small locomotive type boilers for road vehicles which constitute the bulk of the output require a considerably greater amount of labour per ton than is necessary in boiler shops occupied with other types.

The system of payment by results applies to every man in the boiler shop, whether skilled or unskilled, with the single exception of the crane drivers. Even the labourers who sweep up the shops and remove scrap are paid piecework on the number of barrow-loads wheeled out, the price in this case being 1½*d.* per barrow. The men who come in early to light up the fires receive 1½*d.* per fire lit, the window cleaners get so much per window, and so on.

A good idea of the appearance of the boiler shop will be gathered from Figs. 9 and 10 on Plate XLII. The first of these illustrations shows one end of the bay where the heavier presses are situated. These include, amongst others, a 350-ton Fielding and Platt flanging press, which can be seen in the background of the photograph, an overhung press of 120 tons visible in the foreground, and a 133-ton flanging press capable of making a straight flange 15 ft. long in one operation. This latter press is used for making the headers of superheaters and water-tube boilers. The superheater headers, which were going through at the time of our visit, were made from ⅜ in. plate. They were 10 ft. 6 in. long, with a rectangular cross-section measuring 5½ in. by 6¼ in. inside and were closed with a weld running down the centre of one side. The pressing of these headers from a flat plate is carried out in two operations. A plate of the proper width and bevelled on the long edges, is pressed hot into the shape of a rectangular U, and at a second heat and pressing the sides are bent over to form a hollow rectangle. The adjacent edges are then electrically welded together, the gutter formed by the bevels being made up solid with molten metal. The tube holes have then to be made and the inlet and outlet branches welded on. The appearance of the completed header is shown in Fig. 10, in which a pair of them are to be seen lying side by side on the floor.

Referring to Fig. 9, there will be seen lying in the gangway some boiler drums for steam wagons, on which the flat seating for the engine cylinder casting is pressed out of the body of the boiler instead of being riveted on according to the practice still adhered to by other makers. These boiler drums are about ⅜ in. thick, and the seating and semi-cylindrical top half of the barrel are pressed from the flatplate at one operation. The ends of the plate are then bent to form the complete cylinder by rolls in the usual way. Pressed seatings of the type described are a speciality of Messrs. Clayton and Shuttleworth, who have adopted them as standard practice, not merely in the interests of quantity production, but as being a sounder mechanical job than the alternative practice. A flat stiffening plate is afterwards fixed on by means of countersunk rivets, and this forms the actual seating of the cylinders.

The five bays of the boiler shop are all served by overhead electric cranes, ranging from 3 to 20 tons capacity. Numerous jib cranes are also fitted to the walls and internal columns, so that material can be passed from one machine to another, or otherwise handled, in the most expeditious manner. Besides the presses we have mentioned, the equipment of the shop comprises two plate-edge planing machines, with 20 ft. gap, four hydraulic riveting machines, ranging from 8 ft. to 10 ft. 6 in. gap, and numerous pneumatic riveters and caulkers. Machine

riveting is employed wherever possible, and it is also the practice to drill all rivet holes in position, the drilling plant including seven Asquith drills and two Campbell and Hunter horizontal boiler drilling machines with rotating tables. Amongst other machines which deserve special notice are a pair of Wicksteed hack-sawing machines, which are used to trim round the flanges of plates after they have been pressed. These machines do their work at an unusually high speed, removing the ragged edge of the flange at the rate of 5 in. per minute. They will deal with flanged plates up to 1 in. thick, and their work is all that can be desired.

The extent of the boiler shop will be well brought home to the mind by Fig. 10, which is taken from a position in the finishing bay. In this bay the work of riveting, caulking, staying, tubing and testing is carried out. The articles shown in the foreground are tanks for steam wagons. Adjacent to this bay is the electric welding shop. Here the superheater and water-tube boiler headers are welded up and other welding work performed, such as the manufacture of firebox foundation rings, which are composed of four pieces of square section steel welded together at the corners. One of the most interesting applications of electric welding, however, to boiler construction consists in the welding of the firebox roof stays to the crown of the firebox. These stays are flat steel plates on edge attached to the firebox crown by welding their "feet" to the top of the box. A later drawing will make the construction clear, and it may be said that the practice proves entirely satisfactory in actual service. When tested to destruction the plates themselves give way before the welds can be separated. The adoption of welding permits a freer circulation of water over the firebox crown and also does away with the necessity of using studs or set screws to hold the roof stays.

Before leaving the boiler shop some reference must be made to the water-tube boilers now being manufactured by Messrs. Clayton and Shuttleworth. These, which are known as the Spearing boilers, are practically identical in design and dimensions with the large-tube water-tube boilers which have for many years been almost regarded as the standard type for electric power stations. The tubes are of the same diameter and length, hand-hole covers are the same, and, generally speaking, all parts are interchangeable with existing boilers of the same type. This, of course, is a very great consideration with power-station engineers, who are thus able to instal the Spearing boilers side by side with existing plant, and are not compelled to multiply the stock of spare parts to be carried. The only special feature of distinction of the Spearing boiler is that the headers are straight, so that the staggering of the tubes is slightly different. The Spearing boilers are being built both of the longitudinal drum type and the cross-drum type, about 30 being in course of construction at the time of our visit.

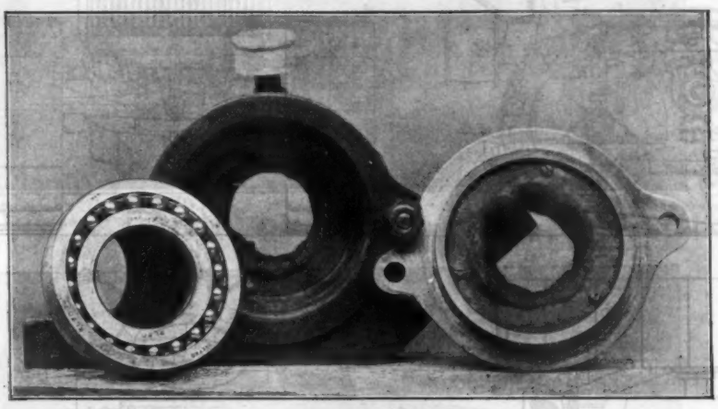


FIG. 11. BALL BEARING FOR THRASHING MACHINE.

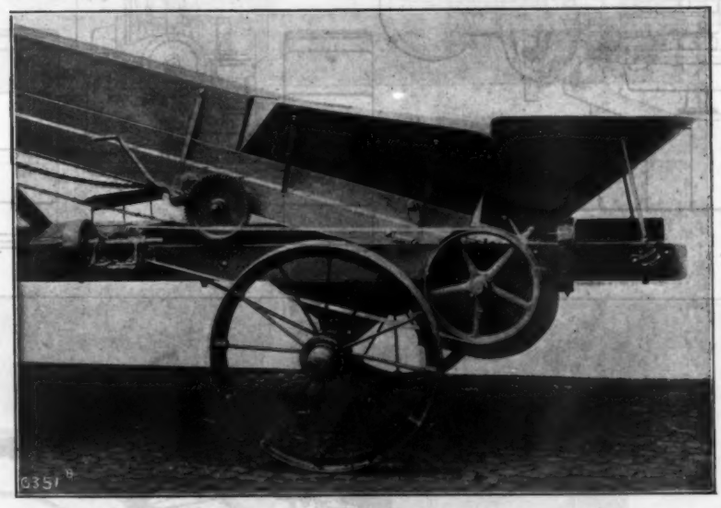


FIG. 12. ELEVATOR ATTACHMENT FOR ENGINE DRIVE.

THE WOOD WORKING SHOPS.

The wood working departments of the Stamp End Works employ between 350 and 400 men. The size and importance of this section will be understood from the fact that the output of thrashing machines alone exceeds a thousand a year, while, in addition to these machines, chaff cutters, maize shellers, clover hullers, riddles, bodies for steam and electric wagons, and trailers all figure largely in the annual production. The machines above mentioned have been largely standardised in type for many years, but minor improvements continue to be made. It is now Clayton and Shuttleworth's practice to fit self-aligning ball bearings throughout their thrashers; these effect a noticeable reduction in the driving power required, and also lessen the maintenance. A thrashing machine contains, of course, numerous high-speed shafts, and the conditions of working are such as to enable the full superiority of ball bearings to be realised. The bearings are of a particularly simple nature, the ordinary standard ring being housed in a dustproof cast iron casing, as shown in Fig. 11. While dealing with this class of agricultural machinery mention may be made of the neat and simple attachment fitted by the firm to their elevators, to enable the old-fashioned horse gear to be replaced by a power drive from a stationary engine or a tractor. This attachment is illustrated in Fig. 12, which is self-explanatory.

One of the most interesting of the wood-working shops is the sawmill, which is illustrated in Fig. 4, Plate XL. The machine in the foreground is a drum sanding machine, and the equipment includes other drum, disc, and belt-sanders. There are also the usual circular and band saws, common to such shops, also planing, morticing and spindling machines. There is a large end-tenoning machine by Messrs. Robinson and Sons, of Rochdale, which will deal with material up to 12 in. by 6 in. in section, and a dimension saw by the same makers has an adjustable table which allows the work to be cut at any angle. A spoke-turning machine of American manufacture should also be mentioned. This which has a cutter the full length of the spoke being turned, is capable of an output of 250 spokes per hour. All machines are driven by independent electric motors, and suitably-placed suction ducts convey all shavings and sawdust direct from the machines to the boiler house some little distance away. This arrangement results in a remarkably clean workshop, in spite of the volume of work going through.

THE CLAYTON CHAIN-TRACK TRACTOR.

The chain-track tractor of Messrs. Clayton and Shuttleworth was originally developed at the instance of the Food Production Department during the war, when it was necessary to greatly increase the quantity of land under cultivation and to do this in the face of a great shortage of agricultural labour. The design, which is illustrated in Figs. 13 to 17, on page 744, was entirely successful, and many hundreds are now at work in this country. The machine is exceedingly compact, as will be gathered from the illustrations. It weighs complete about 5,000 lbs. and is fitted with a 35 h.p. paraffin motor, which enables it to pull a four-furrow plough with ease at the rate of 4 miles per hour. The details of construction will be understood from Figs 18 to 22, page 745, together with the illustrations already referred to. The engine stands on bearers carried by the cast steel side frames, as shown in Figs. 18 and 19, and the drive to the chain tracks sprocket wheel is through a gear box and then by means of the bevel wheel and roller pinions shown in Fig. 20. Each pinion is driven through a clutch, and steering is effected by turning the handwheel shown in Fig. 21, the effect of which is to disconnect the clutch on the side to which the wheel is turned. This stops the chain track on that side of the machine, and the progression of the other track causes the tractor to turn. So effective is this method that the machine can turn about a radius of 7 ft. only. Independent brakes acting on the outside of the clutch drums can be used to assist in making very short turns. Two travelling speeds are provided, namely, 2 and 4 miles per hour, and a reverse speed of 3 miles per hour. A gear-box, illustrated in Fig. 22, contains sliding gears similar to those in a motor car, operated by levers in front of the driver's seat. A pulley is supplied for fastening to the end of the engine shaft immediately beneath the seat, for driving stationary machinery, the engine being capable of working a full-sized thrashing machine in this way when desired. When used as

THE CLAYTON CHAIN-TRACK TRACTOR.

Fig. 13.

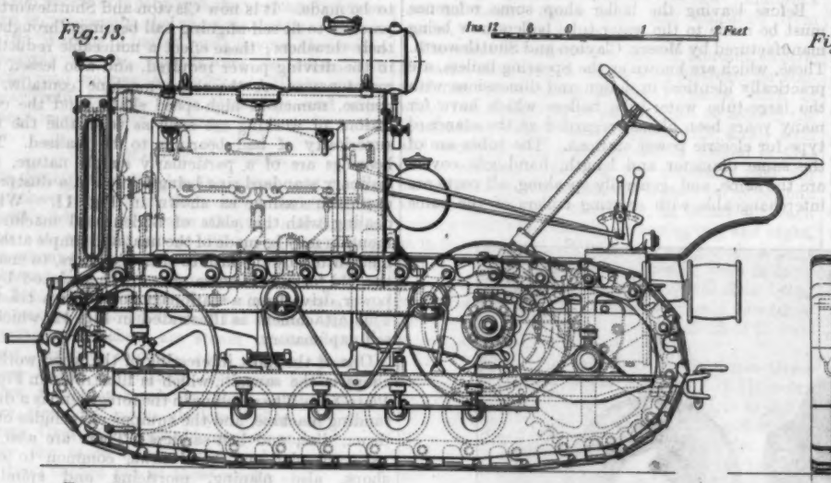


Fig. 15.

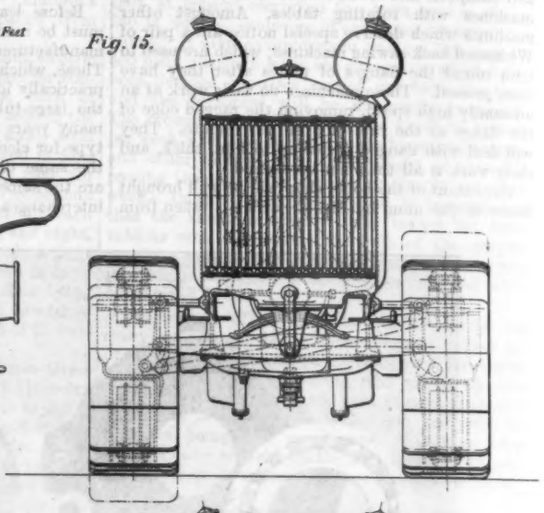


Fig. 14.

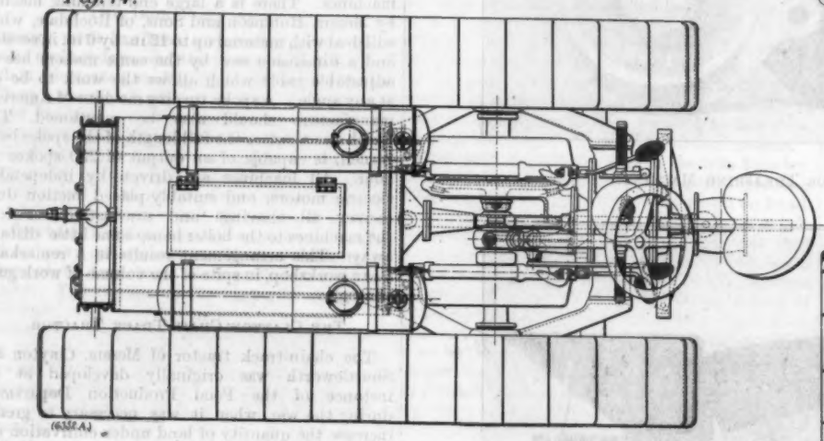
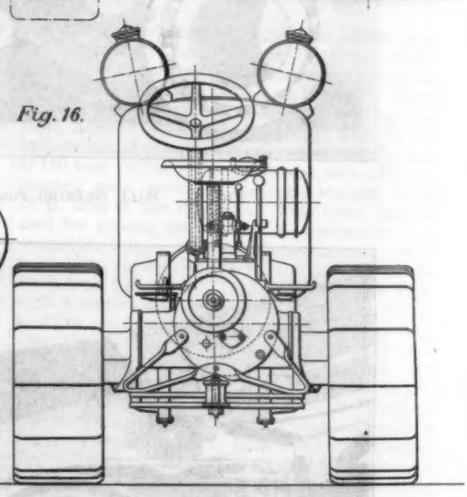


Fig. 16.



a tractor the engine can exert a drawbar pull of 2 tons. Each chain track is 14 in. wide, and the pressure of the machine on the ground is no more than about 2½ lb. per square inch. As this is less than that exerted by the weight of a man standing, it is obvious that the tractor can be driven over soft or marshy ground, across which a man could not walk without sinking in.

THE CLAYTON CRUDE OIL ENGINE.

The Stamp End Works are responsible for a large output of crude oil engines, the design and manufacture of which are under the special supervision of Mr. P. W. Robson, who is the chairman and managing director of the company. These engines are of the horizontal type and are built in standard sizes, which develop from 4 b.h.p. to 75 b.h.p. in a single cylinder, and 150 b.h.p. with twin-cylinders. They work on the two-stroke cycle with hot bulb ignition and run equally successfully with any of the heavy fuel or gas oils. The general appearance of the Clayton engine, as constructed to develop from 11 b.h.p. to 50 b.h.p., is shown in Fig. 27 on page 746, while drawings are reproduced in Figs. 23 to 26 on the same page. A light guard, fixed to the flywheel, normally protects the governor and also covers the gib-headed key on the crankshaft, but this guard has been removed in Fig. 27 in order to show the governor.

The principle of the the two-stroke cycle is too well known to need explanation, especially since on account of the total absence of valves, and the advantage of getting an impulse every revolution, engines of this type have come into such common use. The Clayton engines follow along the generally approved lines, so far as their main feature are concerned, but particular care has been given to details in order that no difficulty shall occur however unskilled is the labour employed. The proper operation of a two-cycle engine of course involves keeping the crank-case airtight, as a pressure of about 5 lb. per inch has to be developed

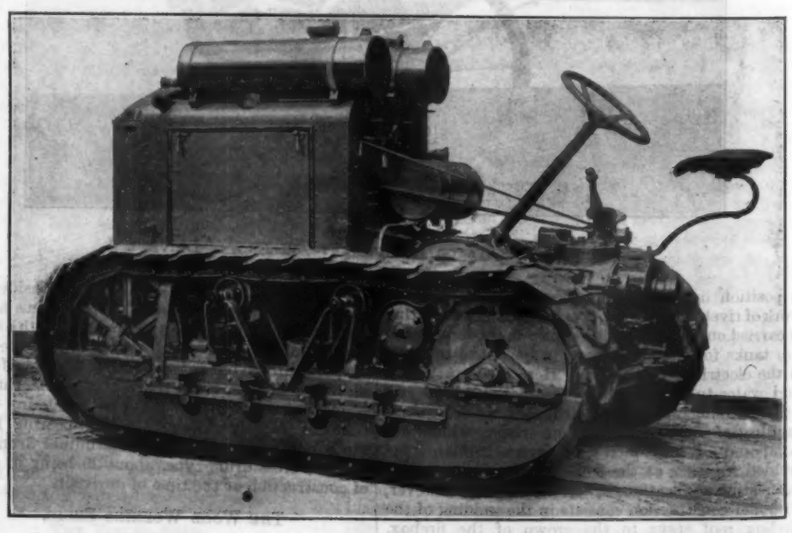


FIG. 17.

DETAILS OF THE CLAYTON CHAIN-TRACK TRACTOR.

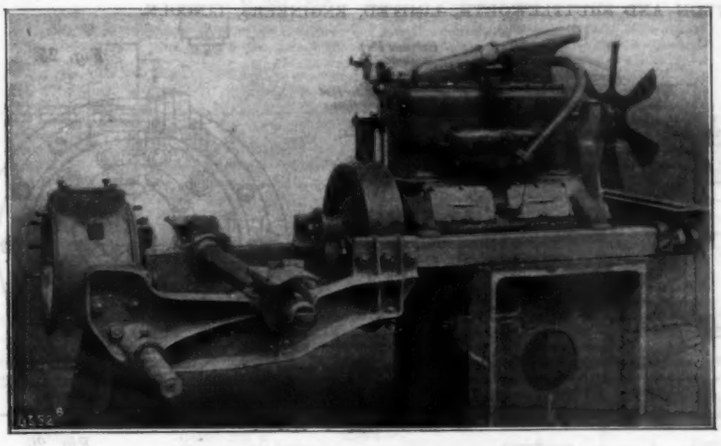


FIG. 18. ARRANGEMENT OF ENGINE.

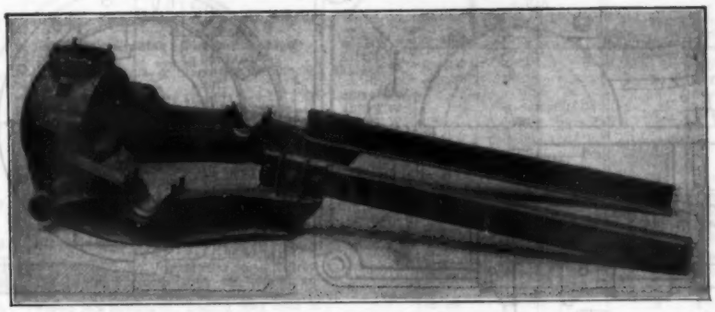


FIG. 19. ENGINE BEARERS AND FRAMING.

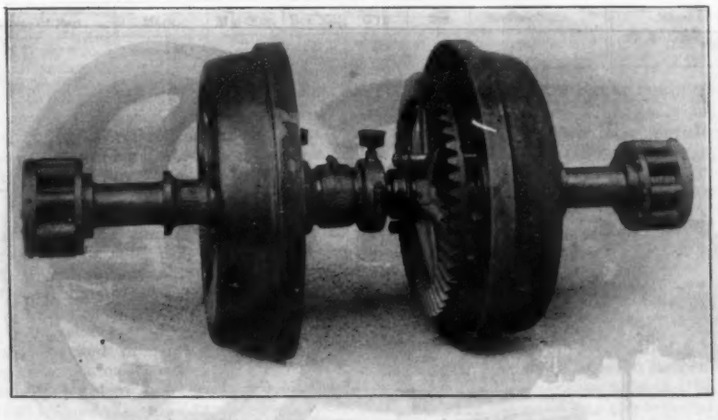


FIG. 20. BEVEL DRIVE AND CLUTCHES.

FIG. 21. STEERING GEAR.

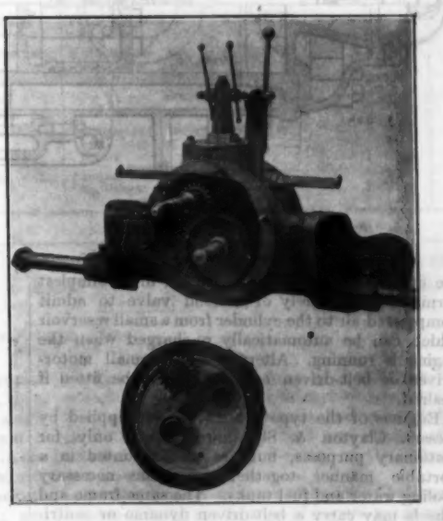


FIG. 22. GEAR BOX.

there on the outward stroke of the piston. The volume of the crank case is necessarily so large, that this pressure can only be obtained if the leakage at the bearings and at the crank case cover is negligible. As the bearings must be capable of adjustment, their design is a matter of importance, and it is frequently very unsatisfactory. In the Clayton engine the crankshaft bearings are made on the sound mechanical lines of those of an open-type engine, the function of the caps being merely to hold the brasses in place. In order to secure airtightness internal annular facings are machined on the cast-iron casing itself, surrounding the brasses, and large hardened washers on the crank-shaft run in contact with these facings. The washers are positively driven and are held up to their work by springs at the back. They carry a leather packing ring which makes a joint between their internal circumference and the crankshaft. They are abundantly lubricated by the crankcase oil and they ensure air tightness permanently without any mechanical difficulty being involved.

The light cast iron cover forming the top half of the crank case can be completely removed by undoing four bolts, when the whole of the working parts of the engine are fully exposed to view. The vertical and horizontal faces of this cover are machined to a templet, the former not being really vertical, but somewhat inclined, so that when the cover is tightened down this joint tends to close. Both joints are packed with asbestos millboard. The main bearings of the engine have ring lubrication, while the cylinder and crank-pin are positively oiled by a mechanical lubricator.

The governing of the Clayton crude oil engines is effected by varying the quantity of fuel injected. A cam on the crankshaft gives a constant reciprocating motion to a lever at the side of the cylinder, and the plunger of the feed pump is actuated by a link, the end of which makes contact with the face of the lever. The action of the governor is to move the end of this link further from or nearer to the fulcrum of the lever, and thus to cause a longer or shorter stroke of the fuel pump. As the link can be freely moved except at the moment of contact with the face of the lever, the governor has no frictional or other work to do, and a very close speed regulation can, therefore, be obtained. It is also obvious that the timing of the explosion is not varied with the amount of fuel injected as the central moment of injection is always the same relatively to the position of the piston.

To start the engine the hot bulb at the end of the cylinder is heated by a blowlamp for a few minutes in the usual way. In the case of engines up to 28 b.h.p. one man can then easily put them in motion by injecting a charge of oil and pulling round on the flywheel, but engines of a larger size

THE CLAYTON CRUDE OIL ENGINE.

CONSTRUCTED BY MESSRS. CLAYTON AND SHUTTLEWORTH, LIMITED, ENGINEERS, LINCOLN.

Fig. 23.

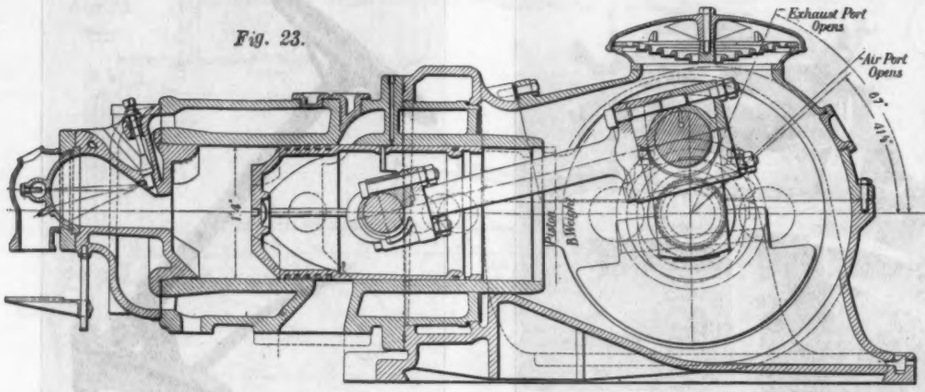


Fig. 25.

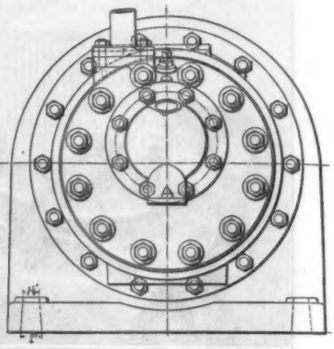
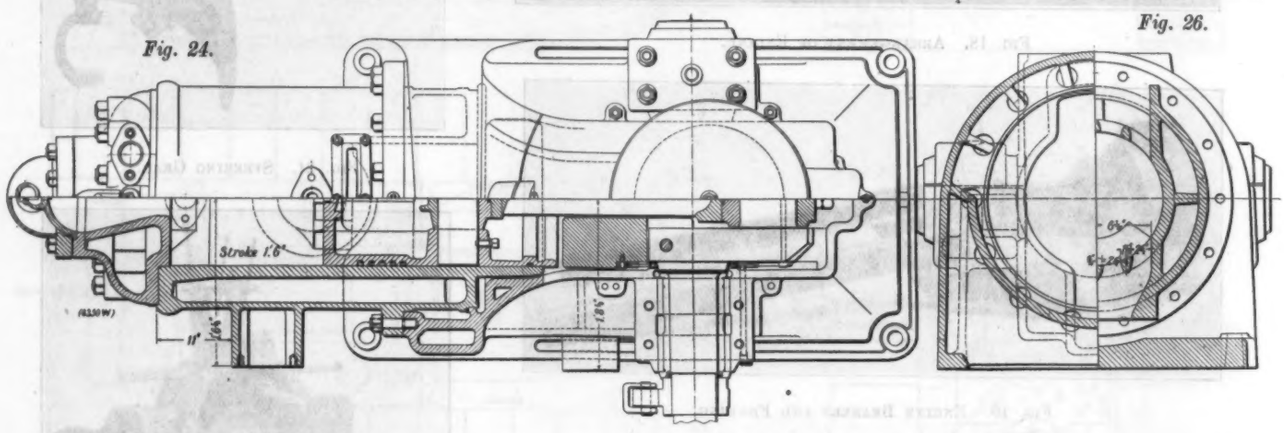


Fig. 26.

Fig. 24.



are fitted with a self-starter. This, in its simplest form, consists merely of a hand valve to admit compressed air to the cylinder from a small reservoir which can be automatically re-charged when the engine is running. Alternatively, a small motor-driven or belt-driven compressor can be fitted if desired.

Engines of the type illustrated are supplied by Messrs. Clayton & Shuttleworth not only for stationary purposes, but are also mounted in a portable manner together with the necessary cooling water and fuel tanks. The same frame and wheels may carry a belt-driven dynamo or centrifugal pump, so that a complete self-contained but portable outfit is provided. The oil engine erecting-shop is illustrated in Fig. 5 on Plate XL, and the machine-shop and testing-bay in Fig. 7 on Plate XLI. All engines before despatch are run on a series of brake tests and indicator cards are also taken to ensure that they shall be in perfect working order and ready for immediate continuous duty when received by the customer.

THE TITANIC WORKS.

These works, the position of which is shown in Fig. 2, page 741, were erected in 1912, and as the principal shop, a structure 1,000 ft. long by 75 ft. wide and approximately the same dimensions as the Titanic which was lost in the spring of that year, the works were named after the famous vessel. During the war the Titanic works were busily engaged in the manufacture of aeroplanes, but no trace of this work remains, and they are henceforth to be devoted exclusively to the production of the Clayton five-ton steam wagon and electric road wagons. The design of the former vehicle has been thoroughly standardised, and its manufacture is being undertaken on the most modern production lines. The main shop, which has been mentioned above, is illustrated in Figs. 28 and 29 on Plate XLIII, the latter view taken from the gallery giving a good idea of the immense length of the building. The whole of the building is not yet fully occupied, as the transference of the steam wagon work from the Stamp End Works is still far from complete. Moreover, one of the shops is at present occupied with testing the Clayton crude oil engines. But as soon as it can be managed, nothing but the manufacture of steam wagons on mass-production lines will occupy the attention of the staff. Already a very good beginning has been made. A large part of the shop is now occupied by new machinery put down specially for predetermined processes, and a comprehensive equipment of jigs and fixtures provides facilities for rapid and interchangeable manufacture.

A planning department decides upon the best methods of manufacture of each detail, the pro-

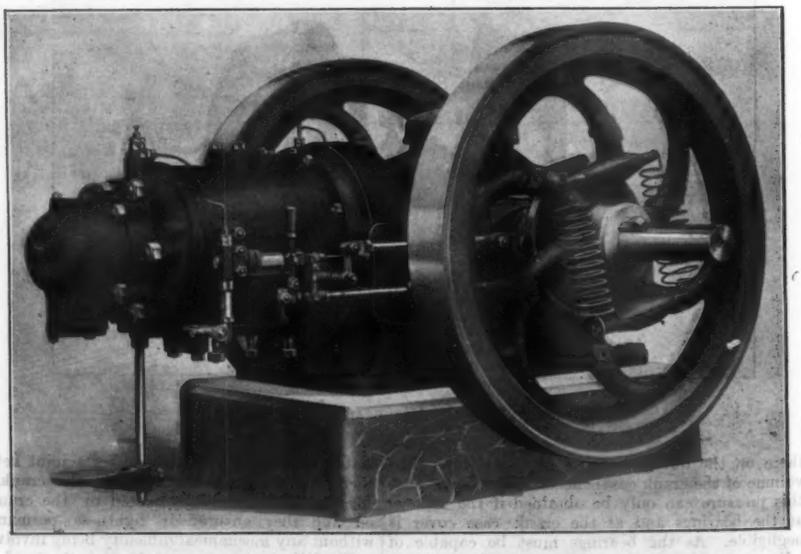
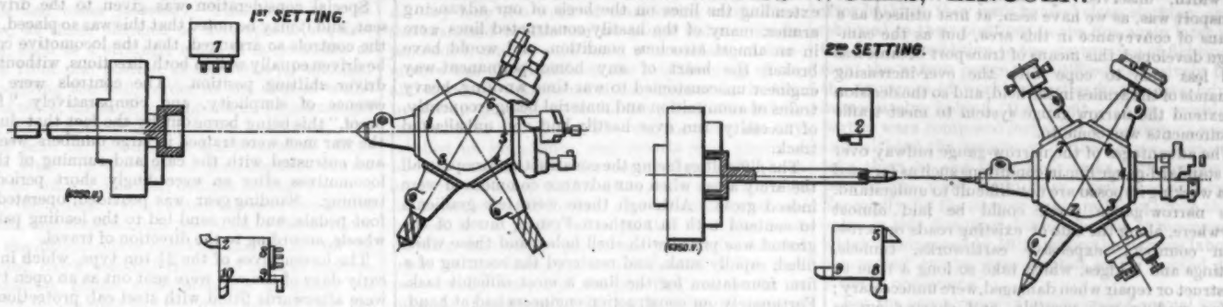


FIG. 27.

MESSRS. CLAYTON AND SHUTTLEWORTH'S WORKS, LINCOLN.



No. 9. COMB. T. L. TOOL. LAYOUT FOR H. P. PISTON. 14131/1.

Sequence No.	Tooling Process.	Description of Tools.	Std. Tools.	Spec. Tools.	Gauges.	Jigs.
	Hold on 4 in. dia. with rod	Chuck jaws &		G. 46		
1	Inwards	Steady bush		G. 80		
	Centre	Centre drill &	12/8/T.W.			
		Holder head in boring bar holder	17/1/T.W.			
2	Rough face end	L.H. turning & facing tool held in sq. turret	40/1/T.W.			
3	Drill 1¼ in. deep, using	1¼ in. drill in bar holder		G. 81		
4	Bore 2 in. dia., using	2 in. boring reamer In bar holder	68/T.W. 17/1/T.W.	G. 6		
5	Trepan 2¼ in. dia. & rough	2 cutters in trepan head	152/4/T.W.			
	Turn 4 in. dia., using	Turning tool 12° TR	40/14/T.W.			
		All held in knee tool	45/1/T.W.			
6	Finish bore & radius &	Turning & facing tool	40/1/T.W.			
	Finish turn 4 in. dia.	Radius tool in holder & turning & facing tool all held	40/2/T.W.			
		In knee tool	45/1/T.W.			
7	Rough form grooves	3 form tools & Packings held in Holder on back slide	152/5/T.W.	G. 37-38 T.Z.		
8	Finish form grooves	3 form tools 3 packings and held in Holder on sq. turret		T.Z. G. 85-86 T.Z.		
9	Cut-off ring in recess	Cut-off tool in sq. turret		G. 83		
10	Finish face bottom of recess and end	Ending tool held in sq. turret		G. 59		

Name of Part.	Mark.	M/c Nos.	Box No.	G'rp	Sec.	Section Title.
H.P. piston	14131/1		2	C	9	Cylinders

No. 9. COMB. TURRET LATHE. LAYOUT. H. P. PISTON. 14131/1.

Sequence No.	Tooling Process.	Description of Tools.	Std. Tools.	Spec. Tools.	Gauges.	Jigs.
	Hold on 4 in. dia. in soft jaws on 15 in. chuck	Std. soft jaws				
1	Centre using No. 25 comb Ck centre drill	Centre drill in holder	60/1/T.W.			
2	Form down for rollers of roller steady turners using form tool in back tool post support on dead centre	Form tool	152/1/T.W.			
		Dead centre	65/1/T.W.			
3	Turn 1·121 in. dia. using	Knife tool in roller stdy. turner	40/15/T.W.			
4	Turn 1 in. dia. using	Knife tool in roller stdy. turner	40/15/T.W.			
5	Form taper using	Form tool held in sq. turret	152/2/T.W.			
6	Face end of rod using	Knife tool in roller stdy. ending tool	40/15/T.W.			
7	Screw 1¼ in. × 11 threads using	1¼ × 11 cov. dies in 1 in. cov. die head	25/14/T.W.			
8	Finish turn & face head	Turning and facing tool held in sq. turret	40/1/T.W.			
9	Form radius under head	¼ radius tool held in sq. turret	152/3/T.W.			

Name of Part.	Mark.	M/c Nos.	Box No.	G'rp.	Sec.	Section Title.
H.P. piston	14131/1		2	C	9	Cylinders

FIG. 30. TOOLING INSTRUCTION SHEET FOR STEEL DROP-FORGED PISTON.

cesses being determined on in the light of the necessity of keeping the whole of the machinery working to its full capacity. How carefully and explicitly the working instructions are provided for the workmen will be evident from Fig. 30, above, which shows the process-cards relating to the machining of a steel drop-forged piston for the steam wagon. It almost goes without saying that all work is remunerated by piecework.

Standard machine-tools rather than single-purpose machines are the rule, along with a systematic method of jigging. The cylinders are designed for through boring, and the two cylinder bores and the two valve bores are all machined at once by means of a jig used in connection with a horizontal boring-machine built by the Dickinson Machine Tool Company, Limited, of Keighley. It is gratifying to observe that the new machine-tool equipment is practically entirely the product of British makers, the superior durability of the British machine under the stress of hard work having been well demonstrated during the war.

(To be continued.)

NARROW-GAUGE RAILWAYS ON THE WESTERN FRONT.

By A. L. STEAD (late Royal Engineers).

IT would be difficult to over-estimate the value of adequate railway communication to modern armies in the field. Upon the same construction and intelligent operation of the railways of all types which form the communication and strategic lines of an army may easily depend the fate of nations. In the annals of the British Army railways have, since the date of their inception, always occupied a most prominent position. The construction, then, unsurpassed in military engineering, of the strategic line of railway up the Bolan Pass, through a waterless desert, which played so important a part in the late Lord Roberts' march to Kandahar; the railway building activities of the late Lord Kitchener, in connection with the conquest of the Soudan; and the more recent railway exploits of the late General Botha in constructing desert lines in South-West Africa; are but three of the many well-known instances of the wonderful work railways have, at various periods, performed in furthering the success of our arms.

During the great war two types of railway were principally used—the standard (4-ft. 8½-in.) gauge, and the narrow (60-cm.) gauge. Of the work of activities of the 60-cm. gauge lines little has, as yet, been recorded. Only where the work of the standard gauge railway ended did the activities of the narrow-gauge commence, and in the area forward of the standard-gauge railheads right up to the trenches, narrow-gauge railways were the principal means of transport utilised for the colossal traffic requiring to be conveyed to and fro' by day and by night. Road motor transport helped in the task, it is true, and in all fairness it must be admitted, performed much useful work. But without the aid of the narrow-gauge railways, the task of the road vehicles would quickly have proved a hopeless one; indeed in the days before the narrow-gauge railways were fully developed, the stock of road vehicles often proved quite inadequate to cope with the enormous quantity of traffic awaiting transport. Many of the important roads became little better than mere quagmires, and so bad were the conditions to be contended with that, after an exceedingly short life, large numbers of motor vehicles had to be relegated to the scrap heap, and there was danger of our communications falling forward of the standard-gauge railheads.

To the French military authorities belongs the honour of being the pioneers of narrow-gauge railway operation in the greatest of all wars, for our gallant allies had been working small systems of 60-cm. line with considerable success before we began operations on the narrow gauge, and it was not until 1917 that we commenced to utilise this form of traction to any appreciable extent. At the beginning of that year there were something like 100 miles of 60-cm. track being operated by the railway troops of the Royal Engineers, and this was little by little increased until in 1918 about 1,000 miles of line were being worked.

The standard-gauge railheads on the Western Front were always located as far forward as possible, and were usually about 8 miles behind our front line infantry positions. Further forward it was not possible to work standard-gauge trains, or to carry on with safety the work of a busy supply or *personnel* railhead. For a time, it is true, in the early stages of the war, before the enemy artillery had begun to practice back-area shelling, it was possible to run standard-gauge trains much nearer the front line positions, and to carry on, almost under the nose of the enemy, the entraining and detraining of troops, and the loading and unloading of supplies in comparative safety. As time went on, however, it was found necessary to move the railheads further back to safer sites. There was thus left a belt of country

stretching the full length of the front, about 8 miles in width, unserved by railways. Road motor transport was, as we have seen, at first utilised as a means of conveyance in this area, but as the campaign developed, this means of transport became less and less able to cope with the ever-increasing demands of the armies in the field, and so the decision to extend the narrow-gauge system to meet traffic requirements was come to.

The advantages of the narrow-gauge railway over the standard-gauge line in conditions such as forward area working imposed are not difficult to understand. The narrow-gauge track could be laid almost anywhere, along the side of existing roads or across open country; expensive earthworks, tunnels, cuttings and bridges, which take so long a time to construct or repair when damaged, were unnecessary; stiffer grading was possible, and sharper curves could be laid than on the standard gauge; the work of traffic control was comparatively simple; a more frequent service of trains than was possible on the standard gauge could be run; and the narrow-gauge railway trains were more difficult for the enemy to detect than the standard gauge, firstly by reason of their smaller compass, and secondly because of their greater freedom from escaping smoke, sparks and steam—a freedom which, with the use of the petrol locomotives, described later, was absolute.

Generally speaking, the enemy did not trouble the narrow-gauge lines in particular with his artillery, except in a few branches in the forward areas, which he had noticed from observation were worked at certain definite hours daily. The reason for his apparent indifference in this respect is not difficult to understand. Except where actual observation was possible, the chances of a shell landing on a narrow-gauge train were somewhat remote, and damage done to the 60-cm. track was quickly repaired by our engineers. Shells from the enemy did occasionally fall directly on to narrow-gauge trains, and on the track, but these were, from his point of view, more in the nature of lucky shots rather than specimens of good gunnery. The whole of the area forward of the standard-gauge railheads was, of course, regularly shelled with greater or lesser intensity, and the narrow-gauge railways took their share of the missiles sent across, in common with other organisations in the area.

The general plan adopted in laying out the narrow-gauge lines on the Western Front consisted of a main line running parallel with the infantry positions and about 8 miles distant therefrom, or roughly in a line drawn through the various standard-gauge railheads. From this, lateral branch lines ran forward in an easterly direction towards the front. Various types of rail were employed, of from 8 lb. weight per yard upwards. The lateral line and the main branches were laid with heavy steel rails, with sleepers of both steel and wood, to which the rails were affixed by bolts and dog-spikes. Many of the rails were shipped out from the English makers in complete sections. The less important branches were of lighter steel, and some of the very advanced lines of tramway track. In the Ypres salient there was, perhaps, a closer network of narrow-gauge railway lines than on any other portion of the Western Front, owing to the enormous number of batteries stationed there, but in many of the other army areas, as, for instance, on the First Army front before Lens, there was an almost equal number of narrow-gauge railway lines serving every nook and corner of the front.

Transhipment sidings were provided at all the standard-gauge railheads, ammunition and engineering material dumps, for the loading of traffic to and from standard-gauge and dumps, and loops capable of holding at least one complete train, constructed as passing places, at frequent intervals along the line. Triangles were also installed at most junctions and railheads in all the army areas. During the period of stationary warfare the greater part of the track, even in the forward area, was quite good, although blow-outs, caused by hostile artillery fire, would often cause slight trouble for a time. The construction gangs were employed daily on maintenance work, and some of the main lines were in almost as excellent condition as those on the standard-gauge railways at home. When, however, the war of movement was in progress, and the whole energies of the construction troops were centred on extending the lines on the heels of our advancing armies, many of the hastily-constructed lines were in an almost atrocious condition, and would have broken the heart of any home permanent-way engineer unaccustomed to war-time working, heavy trains of ammunition and material being frequently, of necessity, run over hastily-laid and unballasted track.

The difficulties facing the construction troops in all the army areas when our advance commenced were indeed great. Although there were few gradients to contend with in northern France, much of the ground was pitted with shell holes, and these when filled, rapidly sunk, and rendered the securing of a firm foundation for the lines a most difficult task. Fortunately our construction engineers had at hand, in the refuse heaps of the French collieries and the ruined villages, much material suitable for use as ballast, and of this they made extensive use.

In most of our advances, the German narrow-gauge railway system was reached, and as the enemy also worked to a 60-cm. gauge, our construction engineers quickly connected up the enemy system with our own, and were thereby saved much labour. The Canadian railway troops, to whom the major part of the work of construction fell, were adepts at laying steel rapidly, and it was largely owing to their efforts that in the later stages of the war our narrow-gauge railways were able to render the valuable assistance they did to the infantry and artillery. That the line was often far from perfectly laid is true, but they enabled the narrow-gauge trains to follow up on the heels of the fighting troops in a wonderful fashion, and eventually the lines were put into something like order for regular running. On all the army fronts one had examples of the Canadians' ability to lay steel with almost lighting-like rapidity.

Both steam and petrol locomotives were used for drawing trains on the narrow-gauge railways. About 500 of the former, shipped overseas complete from the English makers, were of standard design, and do not call for special comment. A good deal of interest, however, attaches to the petrol locomotives, about 400 of which were employed, chiefly on the more advanced lines which were frequently under direct observation from the enemy balloons, and where it would have been foolhardy to run a steam locomotive emitting smoke, sparks and steam.

Of the several types of petrol locomotive utilised on the narrow-gauge railways, the 20 brake horse-power and 40 brake horse-power "Simplex" petrol locomotives, manufactured by the Motor Rail and Tram Car Company, Limited, of Bedford, were used in very large numbers, and gave entire satisfaction throughout. At the outset the War Office ordered a number of "Simplex" petrol locomotives of the 20 brake horse-power open type. These locomotives had to run on tracks originally laid for horse traction and man haulage, and the gross weight of the engine was therefore restricted to 2½ tons. As the elimination of horse traction was proceeded with, however, and a heavier class of rail and better ballasting laid down, it was possible to increase the weight of the locomotives, and further types of 40 brake horse-power petrol engines, weighing from 6 tons to 7½ tons, were introduced. The prime movers in both the 20 brake horse-power and 40 brake horse-power types were internal-combustion engines, which had been specially designed for the work, and were arranged with more accessibility than those of accepted standard design.

The engines were placed across the centre of the frame and were fitted with an extra large flywheel, carrying an inverted cone clutch with Ferodo lining. This permitted the heaviest loads to be got under way with a minimum amount of jar and jolt. The clutch was directly coupled to a gear-box, which consisted of parallel shafts with spur gears mounted thereon. The drive from the gear-box to axles was taken by heavy roller chains, driving all four wheels. The arrangement of fuel tank, radiator and silencer adopted, naturally varied somewhat on the different types. A thoroughly efficient screw brake, with cast-iron brake shoes, was provided, which operated on all four wheels in each type, and was conveniently arranged on each locomotive close to the driver's hand.

Special consideration was given to the driver's seat, and it may be noted that this was so placed, and the controls so arranged, that the locomotive could be driven equally well in both directions, without the driver shifting position. The controls were the essence of simplicity, and comparatively "fool-proof," this being borne out by the fact that during the war men were trained in large numbers weekly, and entrusted with the care and running of these locomotives after an exceedingly short period of training. Sanding gear was provided, operated by foot pedals, and the sand led to the leading pair of wheels, according to the direction of travel.

The locomotives of the 2½-ton type, which in the early days of the war were sent out as an open type, were afterwards fitted with steel cab protection for the driver, which gave the men great confidence in crossing shelled areas. The larger type of locomotive (40 brake horse-power, 6-ton type) had originally a light steel cover for the driver, but in course of time the whole of the locomotive was totally enclosed with ¼-in. steel plate, and experience proved the value of this protective armour.

For the repair of the petrol locomotives there were distributed amongst the armies mobile repair trains, made up in some cases of standard-gauge rolling-stock, and in others of narrow-gauge vehicles. These vehicles were specially constructed for the purpose, and each train formed a complete repair unit. Being always located in the army areas, these trains enabled necessary repairs to be quickly carried out, and the time the petrol locomotives were out of traffic was thus reduced to a minimum. A certain number of steam and petrol locomotives were usually definitely allotted to each of the different operating districts into which the army areas on the Western Front were divided, and in each district locomotive sheds were provided, equipped with inspection pits or ramps, and tools and spare parts for the performance of minor repairs, more important repairs being effected when necessary on the mobile repair trains or at the headquarters' shops of the various armies.

The wagons of various types which were used for the conveyance of traffic over the narrow-gauge lines were almost all built by British wagon makers, and shipped overseas ready for use. They were not usually divided out amongst the districts, a common stock being, as a rule, maintained in each army area. For wagons sent out of one army area to another an equivalent number was usually demanded in exchange, and so each army's stock was maintained. Small wagon repairs were effected in the districts, and more important jobs dealt with at army headquarter shops.

The system of traffic control in operation on the narrow-gauge lines in France was similar in some respects to that employed in certain areas on the home railways. For each army there was what was known as a central traffic control office to supervise inter-army, inter-district, and, to a limited extent, district working. Reporting to this central office were the district traffic controls within the army area, a district usually comprising the lines served from a railhead or group of railheads. Out on the line, at about 2-mile intervals, were other control posts, corresponding to the signal boxes on the home railways, which worked under the supervision of the district traffic control office, with which, and with the control posts on either side, they were in telephonic communication.

All demands for the conveyance of traffic over the narrow-gauge railway system were made by the unit concerned to their corps light railway officer, who acted as liaison officer between the outside units and the railway authorities, such demands usually being due by 4 p.m. for the following day's requirements. These orders gave the name of the unit for whom transport was required, the nature and weight of load, number of wagons required and the hour at which wanted, the loading and unloading points, and the consignee's name. Having received the whole of the day's orders from the various units and formations, the corps light railway officer passed them on to the central traffic control office of the narrow-gauge railway, with an indication as to which orders, if any, should receive priority.

Generally speaking, traffic had priority in the following order: Ammunition, engineering stores, road-making material, supplies, wounded, working parties and other *personnel*. This order was, of course, at times changed to suit special requirements, such as a strategic move of large bodies of troops from one portion of the front to another. On receiving the daily order at the central traffic control office, the work was apportioned out amongst the various operating companies concerned, and details sent to the district traffic control offices in the area. In the case of long-distance moves from one army to another, definite timings were got out by the central traffic control offices of the armies affected, and these timings passed on to the districts.

On the district offices receiving their orders for the following day's working from the central control, the district traffic superintendent prepared his working programme for the day, and advised the district locomotive and tractor officers the number of engines that would be required, and the time and place at which they should be available. Copies of the working programme prepared in the district traffic control office were often sent to these officers, and also to the principal controls in the district for their guidance. Much ingenuity had often to be exercised to fit in all the orders with each other, and to get the maximum work out of locomotives and wagons. As far as possible return loads from the forward lines were obtained for the empties which there became available when the trains going towards the front were off-loaded.

If, as not unfrequently happened, return loads were not available, special efforts were made to get the wagons, off-loaded, in order that they could be at once brought back by the engine which had been employed on the outward journey. Especially did this apply to the uncontrolled area forward of the most advanced control posts, for the difficulty of getting wagons back from this area if left there for some time, and of keeping a check on the wagon stock in the district was, as will be readily understood, considerable. The principal traffics obtained from the forward areas were empty ammunition cases and boxes, wounded and salvage.

The staff in a central traffic control office usually consisted of two officers—one in charge of the traffic working in the area, and the other responsible for the preparation of statistics—and about a dozen non-commissioned officers and men. In addition to keeping records of traffic orders passed to the various district controls, details were also kept of the locomotive and wagon stocks in each district, and adjustments made from time to time as necessary to ensure a fair supply of wagons to all. Records were kept of rolling-stock passing to and from adjoining armies, and losses and gains balanced periodically. In the district traffic control office there were usually working, under the supervision of the district traffic officer, an experienced N.C.O. and half a dozen men. The movement of all trains over the narrow-gauge lines was there recorded in visual form on a control board bearing a map of the lines in the district, in accordance with the telephone reports received from the controls outside, and book records maintained of all traffic handled. The chief duty of the control posts, located at frequent intervals on the line, was to pass trains along the track and report all movements to district control. In the forward area they were usually located in dug-outs, and the most advanced control was responsible for traffic passing into and out of the uncontrolled area which lay beyond. They were visited at frequent intervals by the district traffic officer and his assistants, and a daily ration train usually served to convey to these posts food, water and mails. Fixed signals were not employed on the narrow-gauge lines, except at certain points where the line crossed the standard-gauge railway. At such places semaphore signals were erected, controlled from a crossing-keeper's hut staffed in some instances by the narrow-gauge *personnel* and in others by the standard-gauge staff. At important road crossings flagmen were appointed as a measure of safety.

At the transfer points from standard to narrow-gauge complete staffs of yard-masters, shunters, wagon-labellers, numbertakers, and wagon repairers were usually employed, and these railheads were the busiest places on the narrow-gauge system, with the possible exception of one or two large marshalling yards in certain of the army areas. All day long the work of transferring traffic from the standard to the narrow-gauge railway trucks proceeded, and as each train was made up a locomotive was obtained from the neighbouring sheds, and the traffic despatched either direct to destination by narrow gauge or to one of the principal marshalling yards in the area. The wagons were all fully labelled on both sides, and escorts were provided by the various units for certain traffics such as artillery, rations, ammunition, &c. Ammunition for batteries in the forward area was usually accompanied by a guide, who pointed out the most suitable unloading point, as previously decided upon by the battery. Double-headed trains were occasionally run, but the practice was as far as possible discouraged. On such trains of unusual length a brakesman was provided, who worked under the orders of the guard riding on the last wagon of the train, and from his position on the middle wagon of the train, assisted him in his duties.

There was a good deal of healthy competition between the various armies, and the districts in each army, in their efforts to head the list of traffic carriers. This competition was encouraged by the issue of periodical statistics showing the work performed in the various areas. In considering these figures there were, we are afraid, many who overlooked certain natural disadvantages under which some of the districts worked, such as close proximity to the front, lines under enemy observation, and the like. The line which came out top on paper was not, of course, necessarily the best-managed. The statistics, however, served quite a useful purpose, and their issue was welcomed by all.

In the work of transport in the area forward of the standard-gauge railheads, the narrow-gauge railways were called upon to convey traffic of a hundred-and-one kinds. The principal traffics may, however, be summarised under the following main heads: Ammunition, guns, *personnel*, wounded, rations, engineering stores, poison gas, salvage, and ballast. First and foremost came the ammunition, for the transport of shells to the artillery was the great task of the narrow-gauge railways. The ammunition was, as far as possible, carried to a group of batteries in train loads. Its conveyance was at times a somewhat dangerous task, and the position of the crew of an ammunition train when passing through a heavily-shelled area by no means an enviable one. There was no such thing as halting or turning back when enemy shells commenced to fall in the neighbourhood, for hundreds of lives depended upon the speedy delivery of the train load to the guns. Day and night, in fair weather and in foul, the heavily-laden ammunition trains, with their cargo of high-explosive and gas shells, crept up the narrow-gauge track from the dumps in the rear to the artillery positions, and rarely did they fail to deliver the goods. Many are the stories of hairbreadth escapes from destruction which could be told by the narrow-gauge train crews engaged in the transport of the ammunition, and their determination and bravery knew no limit. The guns, large and small, conveyed over the narrow-gauge railways on wagons specially designed for the purpose, numbered many thousands. In addition to carrying the guns up to their battery positions, the narrow-gauge railways frequently brought them back to the testing ranges which were established in the rear areas, and later returned them to their positions.

The conveyance of infantry and artillery *personnel* to and from the fighting line formed a most important part of the work of the narrow-gauge railways, and millions of troops were so dealt with. The accommodation offered could hardly be called "first-class," packed as the men were 30 to a truck, yet the journey into and out of the line by narrow-gauge train was infinitely preferable to a weary trudge on foot over the shell-torn country. Instead of troops arriving in the trenches worn out with the march from rest-billets, they were able, thanks to the narrow-gauge railway, to arrive fresh and fit. As this branch of narrow-gauge working was developed, it became a common thing in many army areas for infantry to be brought out of the trenches in the morning, conveyed by narrow-gauge train to the bath-houses behind the line, where, after bathing, they were handed clean clothing, and returned to their positions in the line again later in the day. In addition to the conveyance of fighting-men, the narrow-gauge was utilised extensively for the transport of working parties in the area lying immediately behind the front. These working parties were composed largely of low-category men, and without the assistance of the narrow-gauge to take them to and from their tasks, not one-tenth part of the work could have been accomplished. Especially did the narrow-gauge railways prove their value in this direction during the war of movement which commenced in 1918, when the various labour companies' camps were located so far behind the scene of operations.

For the conveyance of the wounded special types of open and closed trucks were employed, some of the latter type accommodating as many as eight stretcher cases and anything up to a score or so of less serious cases. Of the wonderful system of salvaging in operation on the Western Front much has been heard. With this economy campaign the narrow-gauge railways were intimately connected. It was their business to haul the salved material of all descriptions from the battlefields to the standard-gauge railheads, and by their aid large quantities of valuable material were salved and brought down to standard gauge. There the material was sorted, and dispatched in truck loads to the bases at Calais, Boulogne and elsewhere, where it was cleaned and repaired and rendered fit for re-issue. In the war of movement, the narrow-gauge railways conveyed immense quantities of railway and road-making materials up to the forward area, and with their assistance the task of maintaining touch with the advancing troops was greatly facilitated.

With the signing of the armistice the great task of the narrow-gauge railways in France was, of course, completed, but in the clearing-up process which followed, the lines on all portions of the old battle-front rendered valuable assistance in the transport of salvage and working parties, and also helped to relieve the monotony of the lives of the troops stationed in the devastated area by means of regular pleasure excursions run to such neighbouring towns as remained more or less undamaged. The major portion of the work of clearing up was completed towards the close of last year, and the *personnel* of the narrow-gauge railways almost all released from military duties. Many of the narrow-gauge lines, together with large numbers of locomotives and wagons, were handed over to the French authorities, to whom they are now proving of real service in the work of making good the ravages of war. Doubtless, in course of time they will be profitably employed in the transport of manure to the land, agricultural produce to the market, and as feeder lines to the standard gauge.

STEEL WIRE AND WIREDRAWING.*

By E. A. Atkins, A.M.I.Mech.E.

(*Concluded from page* 734.)

Draw-plates.

The draw-plates used in this country are usually of hard steel, but in America and Canada chilled cast-iron plates are very often used for the heavier sizes of wire. The common size of draw-plate is about 10 in. long, 5 in. wide, and 1¼ in. thick, and has 18 holes pierced through it. Outside this size of plate there are small rectangular plates containing a single row of 6 holes, and occasionally small square plates are used having a single hole in the centre. Up to the last few years the draw-plates were made of ordinary straight carbon steel containing about 1·6 per cent. of carbon, but more recently very hard plates have been used, containing up to as much as 13 per cent. of chromium. These give very good results in practice, the hole in the plate "standing up" very well.

The micro-structure of a self-hardening plate is shown in Fig. 20. The white areas in this are intensely hard and, being imbedded in a somewhat softer matrix gives these plates a maximum hardness, together with a fair degree of toughness.

Some wire-drawers prefer to use the older plates for certain classes of work, as they consider that the hole is slightly more elastic, and that the wire does not draw so "harshly." In wire-drawing, the hole in the draw-plate usually enlarges a little after every "piece" is run through, and it is necessary to re-batter the plate and

* Abstract of paper read before the Liverpool Engineering Society, February 18, 1920.

re-set the hole. For efficient working it is essential that draw-plates should be kept in as good condition as possible.

MATERIALS USED IN WIRE-DRAWING.

Mild Steel.—There are several grades of mild steel used in wire-drawing, but, speaking generally, that which is in common use is composed of about 99¼ per cent. of iron, together with a half of one per cent. of impurities, which means to say that a coil of wire of 200-lb. weight, contains 199 lb. of iron, together with 1 lb. of impurities, or other matter. For the sake of comparison it may be mentioned that ordinary hard steel rod is composed of about 98½ per cent. of iron, together with about 1½ per cent. of other constituents, so that, in a coil of wire 200 lb. weight, there would be about 197 lb. of iron, together with about 3 lb. of other kinds of matter. All steels can be considered to have a rock-like formation, and to be built up of crystal grains. Fig. 21 shows a photo-micrograph which exhibits crystal formation of a piece of very mild steel rod. The surface of the specimen was first ground, highly polished, and then lightly etched with acid to bring up its structure. It is shown magnified eighty times across or eight thousand times altogether which will give some idea of how very small these grains are. Perhaps a better way to appraise the magnification is to look upon the real size of the area magnified as being just about that of a dot over one of the "i's" on this page. It will be noticed that the crystal grains all dove-tail into each other like blocks of masonry, and if each one had been free to form its own shape, they would all have been regular in form, but as the steel has cooled down the grains have jostled each other like people in a crowd, and thus have not been free to shape themselves

FIG. 20.

Micro-structure of self-hardening plate, the white areas shown being a double carbide of iron and chromium and are intensely hard. Magnified 80 diameters.

FIG. 21.

Micro-photograph of nearly pure iron rod. Magnified 80 diameters.

FIG. 22.

Micro-photograph of mild steel rod containing 0·20 per cent. carbon. Magnified 80 diameters.

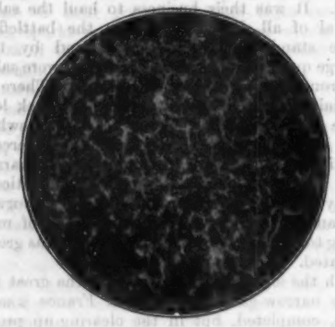


FIG. 23.

Micro-photograph of steel rod containing 0·69 per cent. carbon. Magnified 80 diameters.

(1) (2) (3) (4) (5) (6)

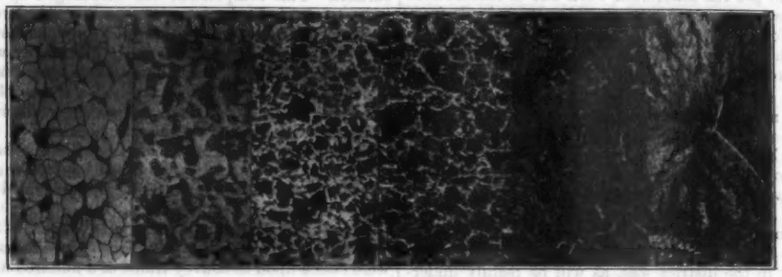


FIG. 24.

Carbon percentages—
0·20 0·35 0·45 0·58 0·75 0·85

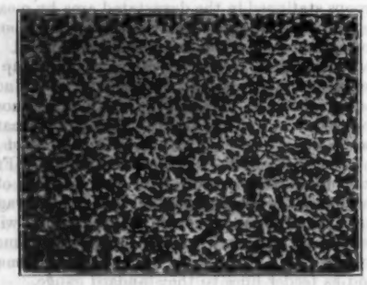


FIG. 25.

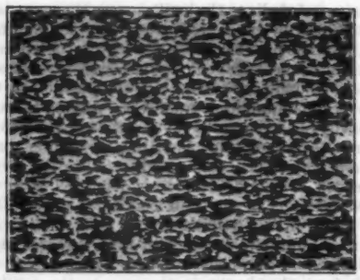


FIG. 26.

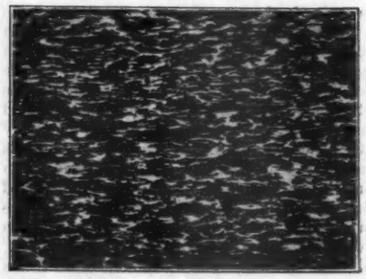


FIG. 27.

FIG. 28.

Micro-photograph of common wrought iron rod. Magnified 80 diameters.

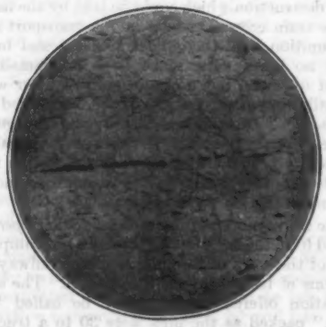


FIG. 29.

Micro-photograph of charcoal iron rod. Magnified 80 diameters.

FIG. 30.

Micro-photograph showing manganese sulphide in mild steel rod. Heat tinted. Magnified 80 diameters.

in a regular way, and have been obliged to take this irregular form and fit in with each other as best they can. It is an exceedingly interesting question as to what it is that keeps the crystal blocks so tightly cemented together. If it were possible to see these little grains jumping through the hole of the wire-drawer's plate as a piece of wire was passing along, about a million of them would be seen to fly through on every inch length of the wire, and as they pass through each little crystal would receive a squeeze that would make it a bit thinner and somewhat longer.

It was mentioned above that the impurities in mild steel amounted to about 0·5 per cent. and in hard steel to about 1½ per cent. What are these impurities or constituents? Usually they are carbon, silicon, sulphur, phosphorus and manganese. The one most prominent at the moment is that known as carbon, as this is the particular ingredient which has the most wonderful effect on the properties of steel, determining the degree of softness, hardness and strength. It seems a somewhat remarkable fact that whilst one steel, which contains about 2 oz. of carbon to 100 lb. of steel, should be soft, another steel, which has about 10 oz. of carbon, is hard and has entirely different properties.

Fig. 22 shows a photo-micrograph of mild steel containing about 3 oz. of carbon to 100 lb. of iron, and it is peculiar to notice that the carbon does not intimately mix with iron. The little black areas in between the crystals contain all the carbon, but it should be definitely understood that these black areas are not carbon in themselves, but are a compound of iron and carbon containing 0·89 per cent., which is about one part of carbon in 110 parts of the steel. The black appearance, it might be pointed out, is caused through the specimen of metal being polished and then etched, the etching process particularly darkening the little areas where the carbon is contained. As the steel increases in the amount of carbon it possesses, the black areas get larger and larger, and the white areas very small, in fact these latter become simply a network. Just as before, the black areas contain all the carbon and with exactly the same per cent., namely, 0·89, the white areas being nearly pure iron, as in Fig. 21.

To show how the black areas increase and the white areas get less, a photo-micrograph (Fig. 23) is shown of a piece of 0·89 per cent. carbon steel. Although this steel contains only 11 oz. of carbon to every 100 lb. of its weight a distinct difference is noticed in the structure from that shown in Fig. 22. The black areas have considerably increased, whilst the white areas have now become a network, only enclosing the parts which contain the carbon. The white areas in Figs. 22 and 23, are practically pure iron, the only difference being that the amount of free iron in the hard steel is very much less than in the case of the mild steel. In passing, it will not be out of place to note that the white areas in steel have given to them the name of "Ferrite," because it is almost pure iron, whilst the black area constituent is spoken of as "Pearlite," because of its pearly appearance when light shines upon it.

Hard Steel.—The great characteristic of high carbon steel is its property of becoming exceedingly hard when suddenly cooled down from the red hot condition in cold water; the degree of hardness depending upon the amount of carbon present in the steel. It is generally thought that mild steel, containing about 0·15 per cent. carbon, does not harden when rapidly cooled out; but this is not quite true, as, whilst in large pieces there is very little hardening effect, yet in small pieces and thin wire there is a greater increase in the hardness. Medium carbon steel of about 0·45 per cent. will, on cooling, harden up considerably, and in the higher carbon steels, say, containing 1·25 per cent. of carbon, quick cooling results in intense hardness.

The structures of the carbon steels alter considerably as the amount of carbon increases, and for purposes of comparison, six photo-micrographs of a magnification of 80 diameters, have been placed side by side in Fig. 24, so that the varying changes in the structure can be seen as the carbon increases from 0·20 to 0·85 per cent. In No. 1 it will be noticed that the white areas (Ferrite) are large, and black areas (Pearlite) small, these latter containing the whole of the carbon. In No. 2 the black areas have increased and the white areas decreased. In No. 5, which is of a 0·75 per cent. carbon steel, it will be noticed that the white areas have decreased so much that the network has disappeared, the free iron now simply being in the form of broken threads. In No. 6, which is of a 0·85 per cent. carbon, there has been almost sufficient carbon completely to saturate the iron; the amount required to do this, it will be remembered from what has previously been said, being 0·89 per cent. Careful examination will show that there is just one little bent white thread of free iron left in the centre of the area. The six photo-micrographs shown are all taken from steel rods, which have been carefully annealed, as this is the only way in which the structures can be properly compared; any difference in heat treatment of the steels causing a distinct difference in the structure. Comparing No. 1 and No. 6, Fig. 24, it will be seen in the case of the low carbon that there are very small areas of "Pearlite," and in the case of the high carbon practically the whole of the area has now become "Pearlitic."

It will be interesting to notice the way in which the structure of a steel rod alters as it is being drawn down into wire. Fig. 25 shows the structure of an untempered rod in which it will be seen that, although the rod was, of course, rolled, the crystals are not elongated, this showing that the rod was rolled at the right temperature, having no work done upon it after the crystals had formed through partial cooling. Fig. 26 shows the same rod drawn to No. 8 gauge. Here it will be seen that the crystals have become elongated and the network squeezed closer together. Fig. 27 shows the same wire carried on without retempering to No. 1 gauge. It will be noticed in this that the network has become flattened out considerably. In cases of over-drawing, the network and crystals are so drawn out that there is partial separation by one part sliding over the other which causes the wire to become fibrous.

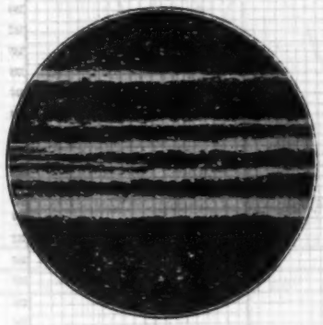


FIG. 31.

Micro-photograph showing phosphor banding in mild steel rod. Etched with Stead's reagent. Magnified 80 diameters.

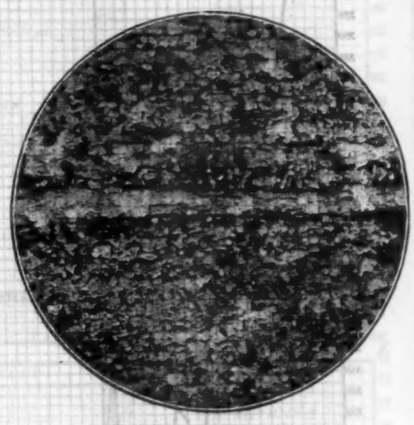


FIG. 32.

Micro-photograph of mild steel rod showing how the phosphor bands cause segregation of carbon. Magnified 160 diameters.

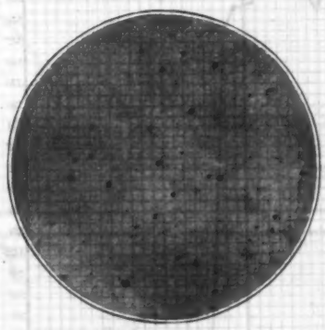


FIG. 33.

Micro-photograph of mild steel rod polished in relief showing black specks of oxide of iron which causes the wire to be larger in gauge at the back end than the front end. Magnified 80 diameters.

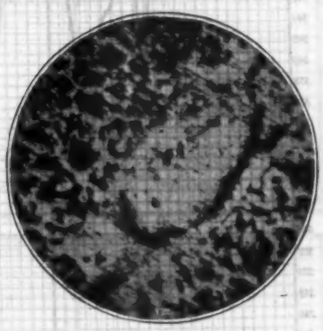


FIG. 34.

Cross-section of wire rod showing "rouke." Magnified 80 diameters.

Wrought Iron.—Common iron is now rarely used in the manufacture of wire, as mild steel has almost entirely taken its place, just as has happened in most other industries. There is a demand for charcoal iron wire for welding purposes, but for the benefit of those concerned it is as well to point out that mild steels are now being made that give results in welding equal to, or better than, those obtained by the use of charcoal iron wire. The difference between wrought-iron and mild steel is very marked, the former due to its method of manufacture being fibrous, whilst the latter is not so. The composition of the two vary very little, yet there is a considerable difference in their properties, indeed, the term "mild steel" is more or less a misnomer, and it has been proposed that "ingot iron" should be substituted for this, so as to avoid any confusion in the use of the term "steel." In the manufacturing of wrought-iron, the pig-iron in the furnace is really never brought to a molten state, but is simply puddled in a pasty form for the removal of a fair proportion of its impurities. The puddled ball or bloom is then removed to be hammered and rolled. In this process further impurities are squeezed out, and those remaining take up the form of slag threads, which are made longer and thinner by rolling and drawing. The structure of a piece of wrought-iron rod is shown in Fig. 28 to a magnification of 80 diameters. Here two large slag threads are seen running lengthways of the rod, and there are also numbers of small slag threads; in between these will be observed the crystals of iron. It should be noticed that these alternate threads or layers of slag and iron give wrought-iron its distinctive property of being fibrous. The good quality of Swedish charcoal iron has been extolled for many years. This fine quality is due to the great purity of the material, and this is seen in the structure of a charcoal rod, as shown by the photo-micrograph, Fig. 29. It will be noticed that the threads of slag are very few and very small as compared with the structures shown on Fig. 28. Also, in Fig. 29, the beautiful crystal formation will be observed, which is always characteristic of a pure iron. The crystal grains here are rather large, but even these amount to about 12,000 to the square inch. In the specimen shown, the total impurities only amount to about ½-oz. in 100 lb. of the metal. In spite of all that has been said about charcoal-iron, one of its defects is want of uniformity in composition.

Special Steels.—Some very special kinds of wire are manufactured from nickel, nickel-chrome and other kinds of steels.

Impurities in Steel as they Affect Wire-drawing.

Of all the manufacturing processes through which steel passes to be wrought into articles of use and commerce, there are none which give it a severer test than wire-drawing. Small defects in steel, which are hardly noticeable when the material is rolled or shaped into great number of things, show up very quickly in the operation of making wire. Pure iron is rarer than gold, and as costly to obtain; therefore, no iron or steel-maker attempts to manufacture his product of a higher degree of purity than is necessary. The impurities found in steel are usually due to their presence in the ore, or in the fuel used in smelting, or are purposely added to give some particular property to the steel, or to neutralise the effect of some other constituent. In analysing steel, the constituents generally determined are: carbon, silicon, sulphur, phosphorus and manganese. In addition to the above, there may also be found copper, nickel, chrome, tungsten, alumina, iron oxide, and such gases as hydrogen, nitrogen and carbon monoxide; all these, in more or less degree, affecting the quality of the steel.

Carbon.—This is never found in the free state in steel, but always in combination with iron, forming the hard carbide of iron. Carbon cannot very well be looked upon as an impurity, since it is purposely added in the medium and higher carbon steels to give hardness and strength. Mild steels usually contain 0·10 to 0·15 per cent., but even these small percentages of carbon make the material somewhat harder than that containing a lower amount. For hard steel wire, the carbon may reach as much as 1 per cent. Segregation of carbon at the core of the wire will cause incipient cuppiness as was shown in Fig. 3.

Silicon.—Any silicon in steel seems to be in complete solution, as it cannot be detected by the microscope, except in the case of slag inclusions. Its effect on the steel is to give increased strength and stiffness; but with the small amounts usually found in ordinary wire—up to 0·10 per cent.—very little difference can be detected in the physical properties.

Sulphur.—This element never seems to go into solution with the steel, but to exist separately as minute globules of iron sulphide, manganese sulphide, or a combination of the two. When in the form of iron sulphide it has the most deleterious effect upon the steel, as this particular compound is brittle. Up to 0·08 per cent. it does not directly affect either the ductility of the metal or its tensile strength. It has some peculiar indirect effects. In the bar, the sulphides exist as small pockets, and these in the rod, if of manganese sulphide become elongated, as shown in the micro-photograph, Fig. 30, to a magnification of 80 diameters. If the small inclusions are composed of iron sulphide, they break up when the steel is worked at a low temperature, or drawn cold. Now, the melting points of the sulphides are comparatively low, 950 to 1,100 deg. C., and if these temperatures

are reached in rolling, the sulphides melt and burst the pockets near the surface of the bar or rod, thus leaving invisible flaws, which open up into what is known as "herring boning" in wire-drawing, as edge-splits in flattening, or split heads in all forms of heading. In all kinds of welding operations, high sulphur in steel causes porous joints through "boiling" of the sulphides. High sulphur also causes trouble through pickling, the sulphur in the pockets near the surface being dissolved, leaving these filled with acid, causing specks, discolouration, &c., in tinned and galvanised wire. Also, it should be noted that, with a high sulphur, it is impossible to obtain a good surface on any form of steel wire—the lower the sulphur the smoother and more silky the surface becomes. Another important point in connection with the effect of sulphur on steel is its action in setting up corrosion, every small speck of sulphur becoming the starting point of corrosive activity.

Phosphorus.—This, as phosphide of iron, is always in solution with some of the iron of the steel, and as it appears to be antagonistic to carbon, the higher the carbon in the steel the greater is the evil effect of the phosphorus. There is no impurity in steel which is more treacherous in its action than this element, for even two steels with exactly the same amounts of phosphorus will show quite different results. These differences are, no doubt, due to the condition of the phosphorus in the steel. As is well known, phosphorus always tends to produce brittleness or cold shortness. As to whether 0·03 per cent., 0·06 per cent., or a higher percentage can be safely used in a particular rod depends upon whether the phosphorus is distributed throughout the steel, or is in a segregated form, also upon the amount of carbon and other constituents present. In wire rods the segregations generally take the form of hard threads, as shown by the white bands in Fig. 31. This form of segregation may cause "cuppy" breaks or make the wire fibrous in drawing, or if the hard bands are on the surface "herring-boning" will result. Fig. 32 shows banding in the structure of mild steel rod. In the banding there will also be seen small threads of manganese sulphide. Small increments of phosphorus increase the hardness and tensile strength, and reduce the ductility of the steel. High phosphorus steel is fatal to good galvanising, the presence of phosphorus opposing the combining of the zinc and iron, peeling and the cracking of the coat being the result. The one advantage that high phosphorus steel has, is in being what is known as "free cutting," so that wire containing up to as much as 0·12 per cent. of phosphorus can be used for automatic machine work, with great advantage from the clear-cutting point of view.

Manganese.—This tends to harden the steel and to increase its strength. One serious defect of high manganese in hard steel is its tendency to make rods or wire much more sensitive to heat treatment, and thus very great care must be taken in the manipulation of high manganese steels.

Nickel.—As an accidental ingredient of steel this is not good, as, like manganese, it upsets the ordinary method of heat treatment, making hard steel more sensitive in tempering, and in annealing offering considerable resistance to low-temperature treatment.

Copper.—Small percentages of this element in mild steel seem to affect adversely its wire-drawing properties, causing the wire to be brittle when drawn down to fine gauges.

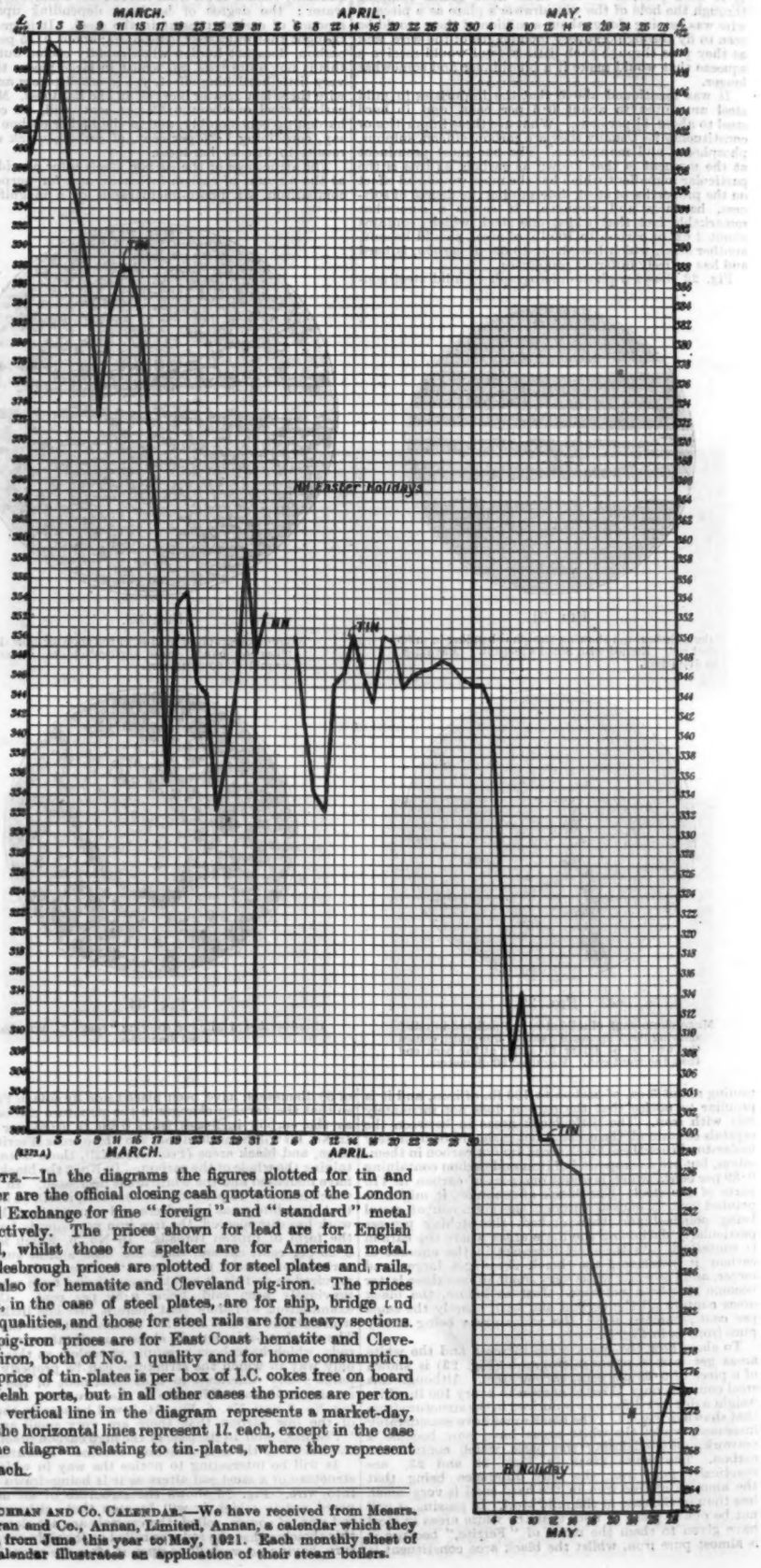
Aluminium.—This is usually found in steel in the form of the hard oxide, and where present, it tends to make the wire "run out," that is, it grinds the hole in the draw-plate larger and results in the back end of the piece of wire being larger in gauge than the front end.

Oxygen.—This element in steel is one of the greatest enemies of the wire-drawer, as it is the principal cause of "running out." The oxygen in the steel is in the form of very small specks of oxide, and these, on account of their hardness, retain their shape, however fine the wire may be drawn. A photo-micrograph to a magnification of 60 diameters, of a small bit of the polished surface of a wire rod is shown in Fig. 33. Here, the small specks are seen dotted all over the surface; for the purpose of showing the vast numbers of these oxide inclusions, it may be said that they calculate out to 150,000 to the square inch of surface; this means that in a cubic-inch of this steel there would be no less than 50 millions of these microscopic globules of oxide. The figures seem almost incredible, but nevertheless they represent facts, it shows the need there is for some reform in the making of steel if perfect material is to be obtained for wire-drawing. The photo-micrograph, Fig. 30, shows the surface of a piece of steel rod of good drawing quality; here there is only one large speck seen, but this represents about 2,000 specks to the square inch. However, as steel rods draw fairly well with even as much as 10,000 specks to the square inch, there is very little disadvantage with the smaller number. The specks act almost like fine emery, grinding the hole in the plate larger as the wire is drawn through. For anything else besides wire-drawing these small oxide inclusions are of very little disadvantage, with the exception of tinning and galvanising; on tinned or galvanised wire they leave small blisters, this being a microscopic blow-hole formed in passing through the baths. As well as affecting the appearance each of these spots forms a centre of corrosion. Oxide of iron, which is rolled into the surface of the rod, is a fruitful source of "roakes" which also cause splitting of the surface on "heading" wire for bolts or rivets. Fig. 34 shows a micro-photograph of a roake as above-mentioned. It may also be mentioned that impurities in steel increase its resistance to the passage of an electric current, so that in wire, used for telegraph and similar purposes, the impurities should be at a minimum.

The thanks of the author are due to Messrs. Rylands Bros., Limited, Warrington, for permission to use the results of experiments carried out in their works.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)

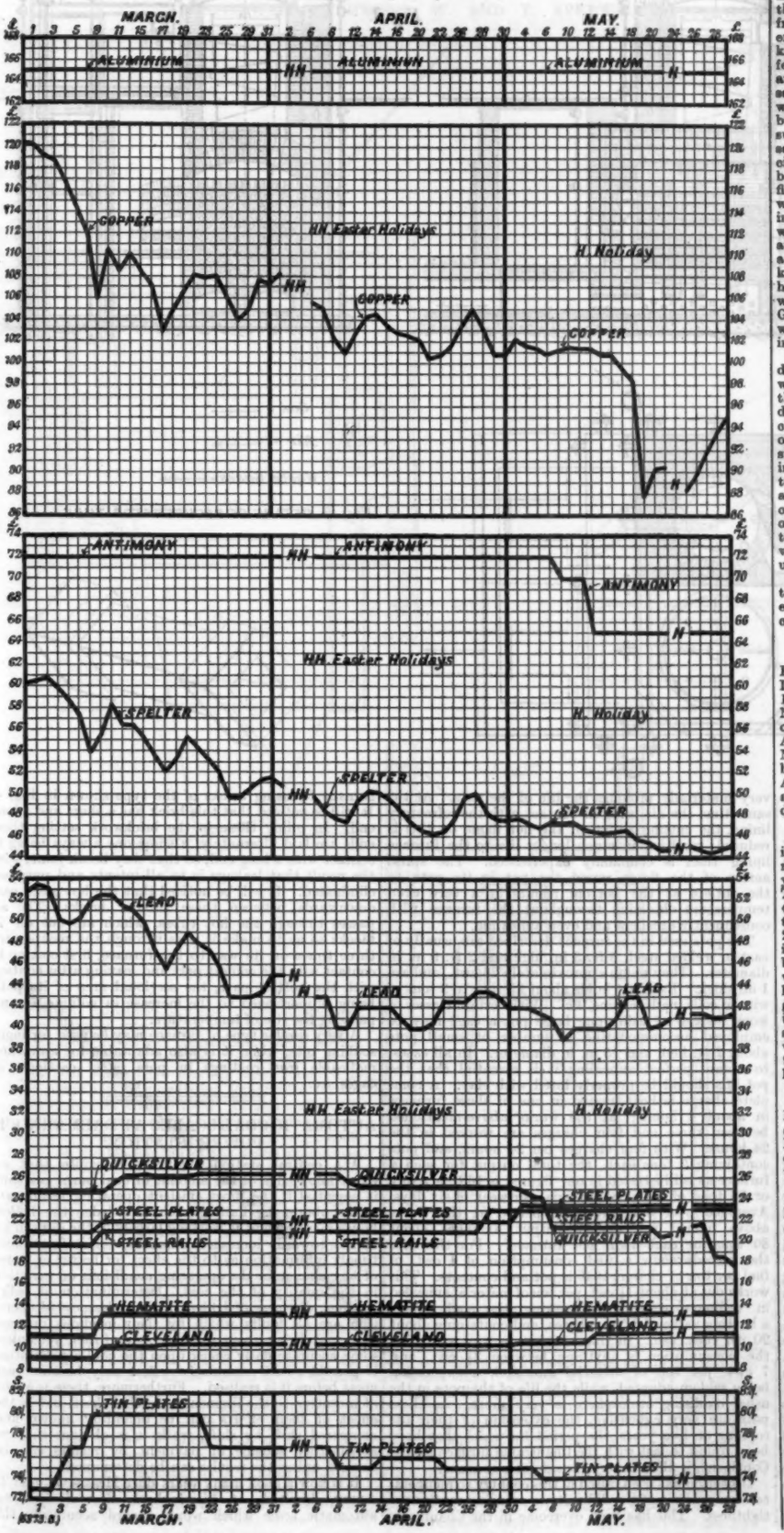


NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates, are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

COCHRAN AND CO. CALENDAR.—We have received from Messrs. Cochran and Co., Annan, Limited, Annan, a calendar which they issue, from June this year to May, 1921. Each monthly sheet of the calendar illustrates an application of their steam boilers.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



DEVELOPMENT OF THE TUNNEL OVEN.*

By Dr. A. GRANGER.

THE principle of the tunnel oven is very simple. The firing places are fixed in the middle of the tunnel, and the material to be fired passes slowly at uniform speed from one end of the tunnel to the other. A continuous enamel kiln with some of the characteristics of a tunnel kiln was built at Vincennes in 1751, but was later transferred to Sèvres, and used there until 1802. In 1809 another enamel kiln on the same principle, but with several improvements, was erected. In 1840, tunnel ovens with other improvements were suggested for firing bricks, but without any practical results. In Germany, O. Bock successfully burned bricks in his tunnel kiln, which had several points in common with the Hoffmann and Licht circular kiln, from which it differed in having a movable bottom and a direct railway. Later Bock adopted gas firing. Some years afterwards Furbringer's enamel kiln was introduced, consisting of a tunnel externally heated in the middle, the ware being placed in iron baskets which traversed the tunnel on a railway; at the entrance and exit of the main tunnel two short tunnels were built at right angles to the main tunnel. This type of tunnel kiln is still used in many works for enamel firing and hardening on. Hetzel designed a circular tunnel kiln, with iron baskets carried on wagons as in the Bock kiln. Geith simplified these kilns by adopting straight tunnels with the baskets sliding on rails, and Larchevêque further improved this.

About twenty years ago, the Faugeron kiln was introduced and tested at Montereau. It consists of a tunnel with the maximum heat in the middle, the ware passing through on small wagons; the gases pass in the opposite direction to a chimney near the entrance. A thick covering of refractory material protects the metallic parts of the wagons from the heat. Iron sheets pass down on each side of the wagons below the refractory covering and dip into sand-filled girders running all along each side of the tunnel, thus excluding cold air. The metal frames of adjacent wagons are connected by asbestos sheets. The circulation of the gases (and therefore heating and cooling of ware) is controlled through the whole length of the tunnel. Many Faugeron ovens or kilns are in use in various places. In England the Dressler tunnel oven is used.

Electric heating should cause great improvement in tunnel kilns of the future, as the author's laboratory experiments at Sèvres have proved that electric heating can give satisfactory results.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—A Southern District meeting of this Institution will be held at Newbury on Saturday, the 12th inst. Members will assemble at the Town Hall, Newbury, at 11 a.m., and will proceed to an inspection of the new housing work which is proceeding in the town. After lunch the reinforced concrete road in High-street, Newbury, will be inspected, and at 2.30 a meeting will be held in the Town Hall, when Mr. S. J. L. Vincent, A.M.Inst.C.E., borough surveyor of Newbury, will read a paper on the carrying out of housing schemes by direct labour.

RADIOTELEGRAPHY IN THE ALPS.—Experiments on the influences of topographical features on the range of radiotelegraphy were conducted in Switzerland last year from 40 stations distributed over the country. The transmitting stations were equipped with plants of 4 kw. and aerials of the umbrella type, 25 m. high; the wave-lengths used varied between 600 m. and 2,100 m. The communication range was, as expected, in general found to be longer at night than in day time, but that did not apply always. Extensive planes, valleys, lakes and water courses increased the range, high mountain chains and also expanses of the firn grainy snow, known as firn, diminished the range; it is considered that in the latter case the air above the snow would be highly ionised. The most intense sounds were obtained with medium wave-lengths of from 900 m. to 1,800 m.; so far, however, the observations hardly justified any general conclusions.

PERSONAL.—Messrs. Siemens Brothers and Co., Limited, inform us that they are taking over the lamp and supplies department of Messrs. Siemens Brothers' Dynamo Works, Limited. Contemporaneously with this change it is announced that the lamps will be sold by the company under the distinctive trade name of "Xcel." As from June 1, 1920, Messrs. Siemens Brothers and Co., Limited, will conduct the business in lamps and supplies from the same addresses in London and the Provinces as hitherto. The company's showrooms are at 38 and 39, Upper Thames-street, London, E.C.—Mr. H. S. Rowell, O.B.E., M.I.Mech.E., A.M.I.C.E., B.Sc.(Lond.), Whitworth Scholar, &c., has been appointed technical secretary of the Research Association of British Motor and Allied Manufacturers, Limited, of 39, St. James's-street, London, S.W. 1, and is taking up his work immediately. Mr. Rowell assisted in the initial researches of the Aeronautics Department at the National Physical Laboratory. Subsequently, after taking up post graduate work at Göttingen and Charlottenburg, he was engaged in teaching and research at the University of Leeds, until the outbreak of war. After serving with the Royal Artillery in Egypt, Gallipoli and France, he was transferred to the Royal Arsenal at Woolwich, where he carried out useful investigations on ammunition. He now relinquishes his position as manager of the Light Engineering Department at the Elswick Works of Messrs. Sir W. G. Armstrong-Whitworth and Co., Limited.

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* Abstract of paper read before the Ceramic Society, at Stoke-on-Trent, April 29, 1920.

THE CHANTRAINE ROTARY FLAME POT ANNEALING FURNACE.

Fig. 1.

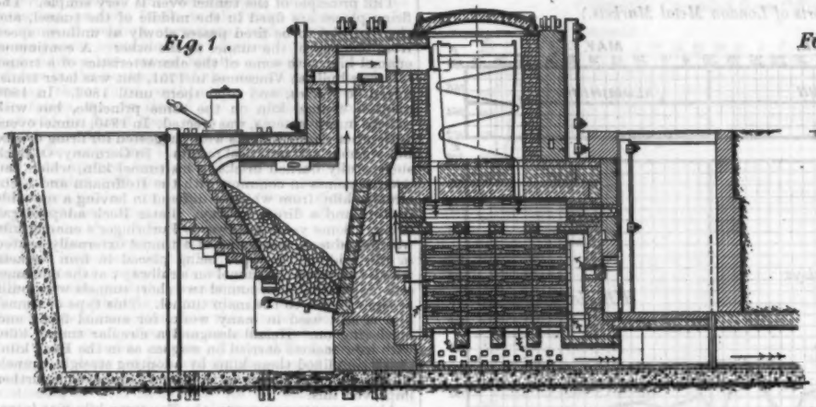


Fig. 3.

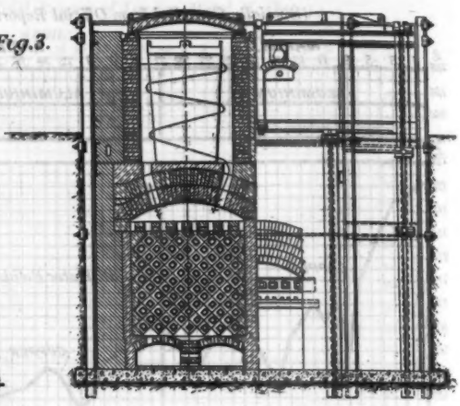
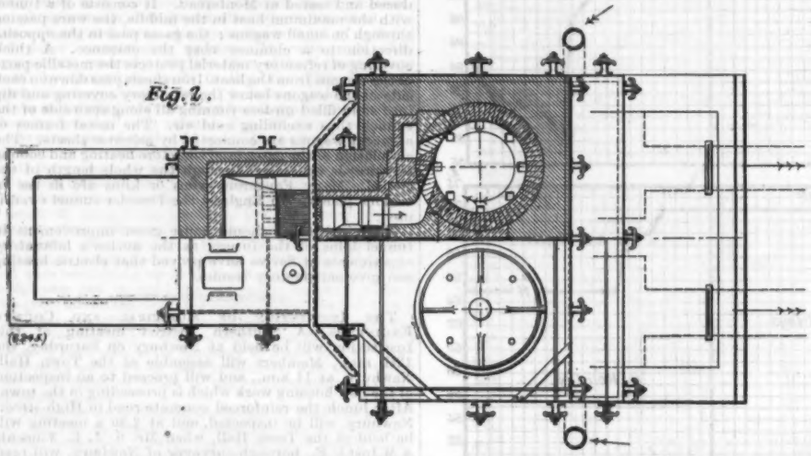


Fig. 2.

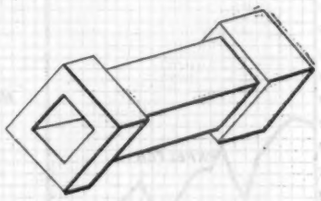


Gas - ——→

Air - ——»

Waste Gases - - -»

Fig. 4. DETAILS OF RECUPERATOR TUBE.



A NEW type of rotary flame pot annealing furnace which has been largely taken up in Belgium, and is now being put down in several plants in this country, is illustrated in Figs. 1 to 4, above. This type of pot furnace has been adopted at the works of the Société Anonyme des Clouteries Mécaniques, Fontaine l'Eveque; the Société Anonyme des Usines Deroq, Fontaine l'Eveque, and others, while a considerable number are being installed in this country, for instance, at the works of Messrs. Richard Johnson and Nephew, Manchester; the Shropshire Iron Company, Limited, Wellington; Messrs. Guest, Keen and Nettlefold, Limited, Smethwick, and so on. It is designed on principles patented by M. A. B. Chantraine, of Marcinelle, Belgium, the rights for this country being in the hands of Messrs. Smeeton-Wright Furnaces, Limited, 56, Victoria-street, S.W. 1.

The construction of the furnace will be clear from the illustrations, Figs. 1 to 3, the arrows marking the course taken by the gas and air, and by the mixture. In front of the furnace, below platform level, is a slow burning gas producer working either with or without steam and using either coke or coal. The gas produced, leaving the producer at about 800 deg. C., is used direct in the adjacent furnace. It passes into the furnace through a tangential nozzle to be seen in the plan, Fig. 2. Immediately ahead of this nozzle is another for supplying the necessary supplementary air. The air comes from a recuperator below the furnace, at a temperature of about 800 deg. C. The mixture is burnt in the space surrounding the pot, forming a continuous spiral flame surrounding it, which finds an exit through a number of ports at the bottom of the furnace through which it passes at a temperature of about 950 deg. C. to 1,000 deg. C. to the recuperator. From this it finally passes to the uptake. The spiral gas flame is arranged, it will be noted, in such a manner that the stream of hot gas is in contact with the pot, while the circular stream of hot air is between the gas and the furnace lining. The effect of this is two-fold. In the first place the air required for combustion has to pass through the stream of gas in order that combustion may be promoted, with the result that a non-oxidising flame is produced with a minimum of excess air. Both the gas and air supplies are regulated by dampers. This non-oxidising flame very materially prolongs the life of the pots. At the same time the air being in contact with the refractory lining, the cutting action of the hot flame on this is reduced, resulting in much longer life to the furnace lining than is commonly experienced. The spiral action of the flame round the pot in its path to the outlets at the bottom results in a very even temperature obtaining throughout the furnace with consequently excellent and even annealing.

The pots used in the furnace described are usually of cast or welded steel, 5 ft. 3 in. high and 2 ft. 9 in. in diameter. They weigh approximately 25 cwt., and are 1 in. thick. Each pot holds about 2½ tons to 3 tons of wire in coils, nails, chains, &c. With certain classes of work instead of using one large pot a cage may be employed accommodating a number of small pots about 2 ft. high and 15 in. in diameter. In all cases, to obtain perfect annealing it is essential that the pot lids should be properly luted with clay. A complete charge is heat-treated in one of these furnaces in about 4 hours; at the works above-mentioned between three and four charges are worked in the 24 hours. With four charges per 24 hours, and pots containing 2 tons each, the total output for such a furnace as is illustrated in our figures is 16 tons a day or 96 tons of annealed material per week of six days. Averaged over a considerable period at the works above named the weekly output averages about 80 tons for each twin pot furnace. For this rate the records show a fuel consumption of 1 cwt. of fuel per ton of charge, that is pot and contents. This works out at about 1¼ cwt. per ton of material annealed in ordinary continuous working, the coal having a heating value of 6,500 calories, and containing about 20 per cent. ash. In this country, in wire annealing the consumption is anything between 3½ cwt. and 7 cwt. per ton of material annealed, recuperation being seldom adopted, while the life of the pots in the usual oxidising atmosphere is very short. As these pots are very expensive, the extension of their life to four or five years, the period for which they have been found to last with the Chantraine furnace on the Continent, is alone a very considerable economy.

Objection has been raised in this country to recuperators on account of the difficulty in securing continuous tightness. This has been overcome in the Chantraine furnace by using bricks of the type shown in Fig. 4. It will be noticed that this brick has a short and a long end. In piling these in the brickwork setting these ends are laid alternately, a short one always being in contact with a long end, so that they break joint, with the result that leakage is to all intents and purposes eliminated. It will be noticed that the hot gases pass downwards between these tubular bricks. The air passes through the hot tubes, which are cut off in blocks so as to make it pass through the recuperator three times on its way to the furnace, first coming in contact with the coolest part and leaving after contact with the hottest part, the sectional area of its path being proportioned to the increase in volume accompanying the rise of temperature.

A very similar type of furnace may be used for ingot soaking pits, while it is also adaptable for annealing malleable iron castings in pots, steel castings in cages, &c.

AUTOMATIC COAL SCALES AT DALMARNOCK POWER STATION.

ALL central station engineers recognise that an exact knowledge of the amount of coal burnt per shift is essential if the most efficient operating results are to be obtained. Failing such knowledge the boiler-house management is working largely in the dark in its efforts towards increased economy, for it is without timely information as to the effect for better or worse of any change in the operating conditions or variation in the quality of the coal. Determination of boiler settings, dirtiness of boilers, and carelessness of operation are all faults which by their insidious increase soon may bring about serious waste of fuel, yet unless some accurate daily check upon the coal consumption is possible, their cumulative effect may become very great before it is realised. Furthermore, there is a lack of incentive to the firemen to do their best, unless the effect of their efforts can be definitely known and compared shift by shift, while it is obvious that no satisfactory scheme of payment by results can be devised unless the results can be determined.

It is now a good many years since Messrs. W. and T. Avery, Limited, of Birmingham, first devised an automatic scale which would record accurately the

AUTOMATIC COAL SCALES AT DALMARNOCK POWER STATION.

CONSTRUCTED BY MESSRS. W. AND T. AVERY, LIMITED, ENGINEERS, BIRMINGHAM.

Fig. 2.

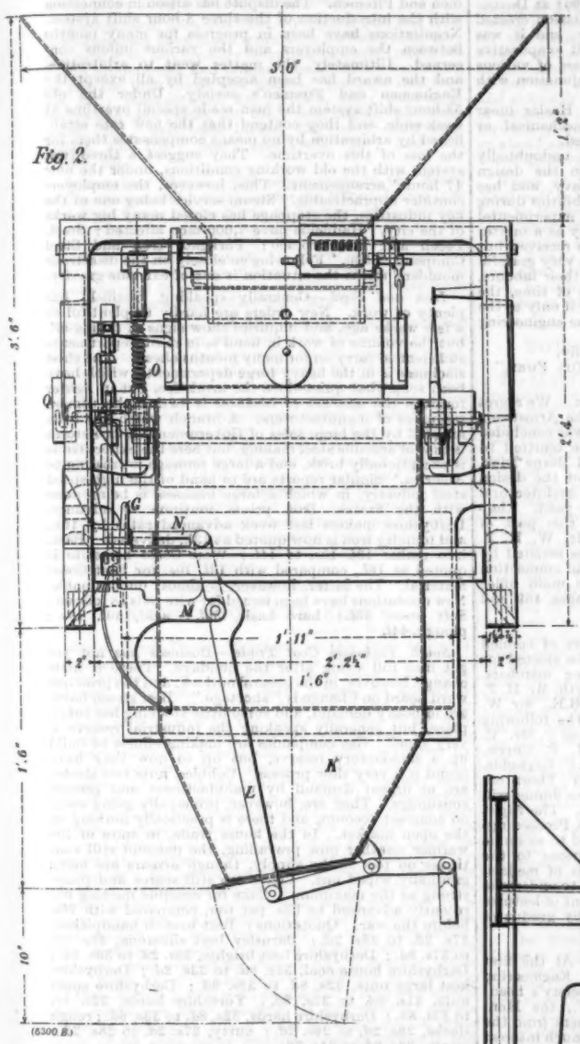


Fig. 3.

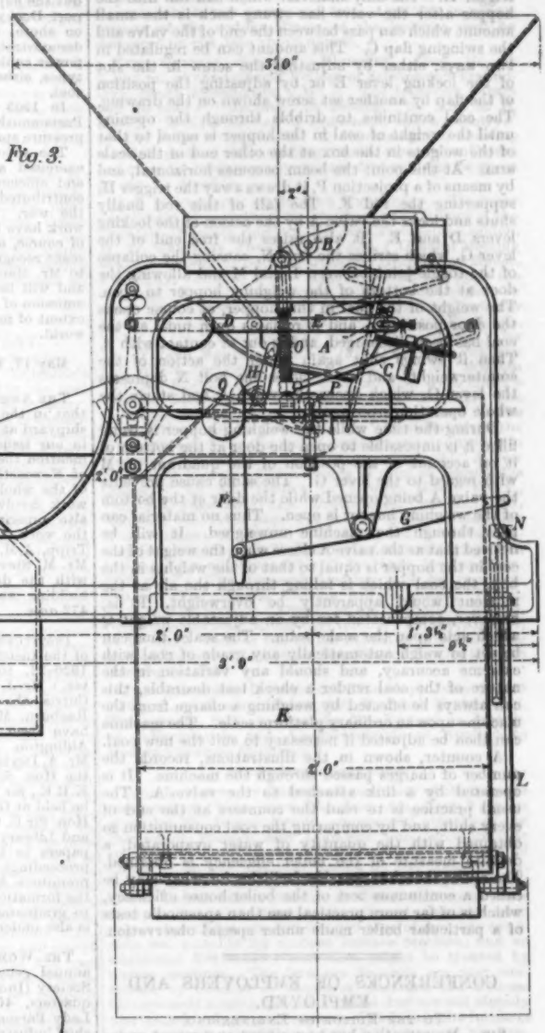
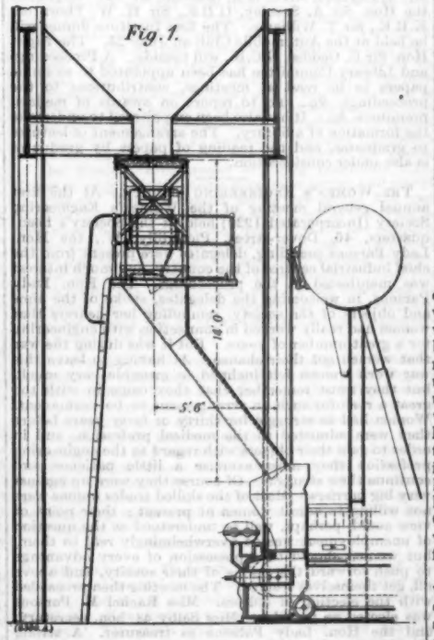


Fig. 1.



amount of coal fed to the furnaces. Such scales have since come largely into use in central stations, the City of Glasgow Electricity Department alone having 80 of such machines in service. Twenty-four Avery automatic coal scales have recently been installed in the large power station now being constructed for the same department at Dalmarnock. In this station the 2-cwt. scale is the type adopted, the general arrangement being as indicated in Fig. 1, on this page, while the details of the mechanism of the scales themselves will be understood from Figs. 2 and 3. At Dalmarnock the usual practice has been followed of fitting one scale for each boiler, although in some stations the scales have been arranged to run on rails, so that each might serve two or more boilers. The fixed scales are suspended from cross girders underneath the bunkers, as shown in Fig. 1, and access to them for reading the counter or for other purposes is provided by means of a light platform. When in use the scales weigh and discharge coal in lots of 2 cwt. each, the whole operation being entirely automatic and the frequency of weighing and discharging being dependent only upon the rate at which the coal is consumed by the furnace. The coal valves at the outlets of the bunkers are left permanently open.

At the top of the scale is a pyramidal hopper, 3 ft. square at the mouth, into which coal falls from the bunkers. This hopper is always full of coal. The lower end of the hopper forms a shoot from which the flow of the coal is regulated by a curved, weighted valve A, which is hinged at B, and a swinging flap C. The valve A is shown closed and in contact with the flap, in Fig. 3. The two levers D and E are jointed together and the outer end of D is hinged to the cast-iron frame of the machine. A pin projecting from the valve A engages with a slot in the end of the lever E, and when these "locking levers" as they are called, are in the horizontal position shown, the valve is prevented from opening. To the joint of the locking levers is attached a vertical rod F, the lower end of which is connected to the hand lever G. If the latter is depressed, the valve A is opened through the action of the vertical rod and the locking bars, and a roller fixed to the side of the vertical rod eventually rests upon the trigger H, and holds the valve open.

The weighing hopper K is suspended from the end of an equal armed cast-iron lever, mounted on knife-edges, and hung from the other end of the lever are the weights against which the coal is weighed. The weights are contained in a box which exactly counterbalances the hopper K. The top of the weight box is made sloping at such an angle that no dust can collect upon it, and a hinged lid fitted with a lock prevents any unauthorised person tampering with the weights.

The lower end of the weighing hopper is closed by a hinged door which, when open, has a slight tendency to close under the action of the counterweight shown in Fig. 2. The rod L is attached at its lower end to the hopper-door lever, and at its upper end to a bell-crank lever M hinged to the hopper and carrying a quadrant. Connected to the upper end of L, there is also a bolt N which, when the machine is working, engages with the free end of the lever G.

The action of the scale is as follows. When the weights are placed in the weight box, the left-hand end of the scale beam is depressed, until projections on the side of the weight-box rest in seatings formed in the cast-iron frame of the machine. The other end of the beam rises, bringing, of course, the hopper K with it. A projection on this end of the beam comes into contact with the lower end of a plunger rod O and attempts to open the valve A, but as this valve is held shut by the locking levers D and E in the manner already described, the only effect is to compress the spring around the plunger rod. The spring also prevents the end of the beam rising suddenly and giving a jar to any part of the mechanism.

If now the end of the lever G is depressed, the rod F is raised and collapses the locking bars, freeing the valve A, which, under the action of the spring, flies wide open. A copious stream of coal at once falls into

the hopper K. As the hopper fills, the beam descends until it ceases to support the valve, which swings back and closes as far as it is permitted by the slot in the locking lever. These locking levers are held in a collapsed position by the rod F being engaged by the trigger H. The only material which can fall into the hopper after the valve has swung back is the small amount which can pass between the end of the valve and the swinging flap C. This amount can be regulated in two ways, either by adjusting the screw in the slot of the locking lever E or by adjusting the position of the flap by another set screw shown on the drawing. The coal continues to dribble through the opening until the weight of coal in the hopper is equal to that of the weights in the box at the other end of the scale arm. At this point the beam becomes horizontal, and by means of a projection P, it draws away the trigger H, supporting the rod F. The fall of this rod finally shuts and locks the valve A by the action of the locking levers D and E. It also raises the free end of the lever G, which strikes the bolt N, causing the collapse of the toggle joint between L and M and allowing the door at the bottom of the weighing hopper to open. The weight of the coal in this hopper, of course opens the door positively, and it remains open until all the coal has been discharged, and is out of contact with it. Then it swings shut again under the action of the counterweight, and as it closes the bolt N depresses the lever G, which opens the valve A and starts the whole operation over again.

During the time while the weighing hopper is being filled it is impossible to open the door at the bottom of it on account of the position of the quadrant on M with regard to the lever G. The same cause prevents the valve A being opened while the door at the bottom of the weighing hopper is open. Thus no material can pass through the machine unweighed. It will be noticed that as the valve A closes when the weight of the coal in the hopper is equal to that of the weights in the box, the coal which is falling through the air at the moment would apparently be overweight. It is, however, compensated for by an adjustable weight Q which acts upon the scale beam. The scales thus can be set to weigh automatically any grade of coal with extreme accuracy, and should any variation in the nature of the coal render a check test desirable, this can always be effected by weighing a charge from the machine upon an ordinary platform scale. The machine can then be adjusted if necessary to suit the new coal.

A counter, shown in the illustrations, records the number of charges passed through the machine. It is operated by a link attached to the valve A. The usual practice is to read the counters at the end of every shift, and by comparing the coal consumption so obtained with the quantity of water evaporated, a definite measure of the boiler efficiency is obtained. The scales therefore provide facilities for what may be called a continuous test of the boiler-house efficiency, which is of far more practical use than spasmodic tests of a particular boiler made under special observation.

CONFERENCES OF EMPLOYERS AND EMPLOYED.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been drawn to a report under Industrial Notes published in the issue of ENGINEERING of May 21, page 680, with regard to the National Alliance of Employers and Employed. In one section you will note it is stated: "The National Alliance justly claims to be the only organisation which can provide the machinery for a round table conference of employers and employed."

I feel sure this has been inserted in error, and should therefore be greatly obliged if you would point out in your next issue that the Industrial League and Council, which is engaged in this work, has been in existence since 1915, and is an organisation well known to the public, its Presidents being the Right Hon. G. H. Roberts, M.P. (ex-Minister of Food) and the Right Hon. J. H. Whitley, M.P. (Deputy-Speaker of the House of Commons). The primary work on which the Industrial League is engaged is to encourage the establishing of Whitley Councils, which are the effective channels of round-table conferences of employers and employed.

Yours very truly,
JOHN AMES, General Secretary.

June 1, 1920.

OIL FUEL IN BRITISH WARSHIPS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the paper recently read by Mr. W. W. Marriner before the Institution of Engineers and Shipbuilders in Scotland, and published in your issue of April 30, page 578, the following paragraph occurs:—

"The adoption of oil fuel was perhaps the next great step forward in the evolution of destroyers, and an enormous amount of credit is due to the Admiralty Experimental Station at Portsmouth which brought oil-fuel burning apparatus to the perfection which is now known.

"One cannot help feeling that there must be some engineer officers whose names ought to be made public so that due honour might be paid them for their work in connection with one of the greatest improvements in war vessels, especially as it placed this country far ahead of the rest of the world for many years."

Twenty years ago the employment of oil as a fuel in naval boilers was regarded as a beautiful dream. It was about this time that preliminary trials with oil fuel were commenced at Portsmouth in the destroyer Surly, but the experiments began in earnest in 1901 at Devonport Dockyard. There, in a boiler installation erected on shore, important progress was made, and it was demonstrated beyond doubt that the full evaporative power could be obtained from naval boilers of various types, either with oil fuel alone or in conjunction with coal.

In 1903 the work was transferred to Haslar (near Portsmouth), where the principle of mechanical or pressure spraying was evolved and perfected.

The success of these experiments has undoubtedly exercised a most important influence on the design and efficiency of ships of the British Navy, and has contributed largely to their steaming capabilities during the war. The valuable results of this experimental work have been accepted by the Admiralty as a matter of course, and the officers concerned have received but scant recognition. They will, however, be very grateful to Mr. Marriner for his kind reference to their labours, and will hope that, even after this lapse of time, the omission of the Admiralty may be repaired if only to the extent of making their names known to the engineering world.

Yours faithfully,
May 17, 1920. "OIL FUEL."

THE ARMSTRONG SHIPYARD: ADDENDUM.—We regret that in the series of articles describing the Armstrong shipyard at High Walker-on-Tyne, which was concluded in our issue of May 21, on page 698, we omitted to mention the fact that Messrs. Cackett and Burns Dick, of Newcastle-on-Tyne, were responsible for the design of the whole of the civil engineering and architectural work involved in the construction of the yard. They also superintended the carrying out of this part of the work, their resident engineer being Mr. W. H. S. Tripp, A.M.I.C.E., A.M.I.Mech.E., who was assisted by Mr. M. Stevenson. The work of the firm in connection with the design and construction of the main office building was, however, referred to on pages 469 and 472 *ante*.

INSTITUTE OF TRANSPORT.—Six members of council of the Institute of Transport will have to be elected for 1920–21, to replace the following retiring members, viz.: Mr. J. Bagwell, Sir A. Kaye Butterworth, Mr. H. P. Currie, the Hon. Sir Arthur Stanley, G.B.E., Sir W. Raeburn, M.P., Mr. G. Renwick, M.P. The following have been nominated for these vacancies: Mr. C. Aldington, C.B.S., Mr. P. Burtt, Mr. H. P. Currie, Mr. A. Dryland, Mr. C. le M. Gosselin, Mr. R. C. Reynolds, the Hon. Sir A. Stanley, G.B.S., Sir H. W. Thornton, K.B.E., Sir T. Williams. The first Institute dinner will be held at the Automobile Club on June 25. The Right Hon. Sir E. Geddes, G.C.B., will preside. A Proceedings and Library Committee has been appointed to examine papers to be read at meetings, contributions to the proceedings, &c., and to report on awards of medals, premiums, &c. It has also been empowered to undertake the formation of a library. The arrangement of lectures to graduates, and the reading of papers by graduates is also under consideration.

THE WOMEN'S ENGINEERING SOCIETY.—At the first annual general meeting of the Women's Engineering Society (Incorporated 1920) held at the Society's headquarters, 46, Dover-street, Piccadilly, W., the Hon. Lady Parsons presiding, delegates were present from the chief industrial centres of the country, and much interest was manifested in the proceedings. The Hon. Lady Parsons, in welcoming the delegates, spoke of the aims and objects of the society, reminding her hearers that women had really worked in connection with engineering for a great number of years. But it was during the war that women got their chance. At having to leave this war work women felt inclined to grumble very much, but they must remember that they came in with too great a rush for such an arrangement to be permanent. Women had to struggle for thirty or forty years before they were admitted to the medical profession, and in order to gain their objects with regard to the engineering profession they must exercise a little patience and continue their struggle. Of course they were up against very big barriers. Most of the skilled trades unions were not willing to admit women at present; their point of view could, perhaps, well be understood as the question of unemployment was so overwhelmingly real to them, but women should take possession of every advantage to push forward the claims of their society, and above all, get themselves trained. The meeting then proceeded with the election of officers. Miss Rachel M. Parsons was elected as president, Miss Selby as hon. secretary, and the Hon. Lady Parsons as treasurer. A strong council was also elected. The annual report was submitted by Miss Haslett (organising secretary). This stated that the society was growing in strength, that a good deal of spade work had been necessary, but numerous indications had already been received showing that this work was meeting with success. Meetings had been held during the year, and in December the society commenced to publish a small quarterly entitled the "Woman Engineer." A club room had been opened at 46, Dover-street, where technical books and papers were available for the use of members. Subsequently, the present position of women in the various branches of engineering was discussed, and it was stated that several institutions of engineers had opened their doors to women, and that members of the W.E.S. had already been admitted to these institutions.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Steam Service Strike.—Twenty thousand men are idle in Sheffield to-day, owing to a strike of the steam service members of the National Amalgamated Union of Enginemen and Firemen. The dispute has arisen in connection with the introduction of the three 8-hour shift system. Negotiations have been in progress for many months between the employers and the various unions concerned. Ultimately, the matter went to arbitration, and the award has been accepted by all except the Enginemen and Firemen's society. Under the old 53-hour shift system the men made special overtime at week-ends, and they contend that the new rate established by arbitration by no means compensates them for the loss of this overtime. They suggest a three-turn system with the old working conditions, under the new 47 hours' arrangement. This, however, the employers consider impracticable. Steam service being one of the key industries, the stoppage has closed many big works of the city. Hadfields have 7,000 men affected; Steel, Peech and Tozer, 5,500; Parkgate Iron and Steel Company, 2,500. Following so closely on the disastrous moulders' strike the situation is one of extreme gravity.

Iron and Steel.—Generally speaking, Sheffield has plenty of work. New orders are hardly as plentiful as a few weeks ago, and inquiries show signs of falling-off, but the volume of work in hand is in most departments sufficient to carry on for many months ahead. The chief slackness is in the heavy forge departments, which have been somewhat quiet since the armistice, but in lighter forgings the amount of business is taxing the utmost resources of manufacturers. A branch which has been affected by the large sales of Government service stores is that of crucible steel making, but here the export trade is exceptionally brisk, and a large tonnage is crossing to America. Similar reports are to hand of the high-speed steel industry, in which a large business is being done with the States. Iron prices continue to advance. Derbyshire makers last week advanced rates by 15*s.*, and foundry iron is now quoted at 13*l.*, delivered. Basic iron makes 13*l.* 10*s.* to 14*l.*; West Coast hematite is quoted at 16*l.*, compared with 13*l.* 10*s.* for East Coast material. The latter, however, is almost unobtainable. New quotations have been issued for wire rods as follows: Soft basic, 35*l.*; hard basic, 36*l.*; acid, 40*l.* 10*s.*; plough, 44*l.*

South Yorkshire Coal Trade.—Business has not yet got into full swing after the holidays. There is little change, however, in the general outlook, and the principle word heard on Change is "shortage." Best steam hards are in heavy demand, and some little stocking has taken place, but generally speaking the industrial reserve is very small. Gas companies are making efforts to build up a satisfactory reserve, but up to now they have found it a very slow process. Cobbles, nuts and slacks, are in urgent demand by manufacturers and general consumers. They are, however, principally going away on contract account, and there is practically nothing on the open market. In the house trade, in spite of the warmer weather now prevailing, the demand still continues on top of the supply, though arrears are being gradually wiped out. Cokes are still scarce and prices strong at the maximum. Coke for crucible melting has recently advanced to 92*s.* per ton, compared with 26*s.* before the war. Quotations: Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The Cleveland pig-iron trade presents no new feature of moment. Scarcity continues most marked, and lack of railway facilities continues to seriously hamper delivery of iron available for distribution. Home needs are such that they fully absorb what iron is obtainable, and consequently it is not at all surprising to find makers still adhering to their decision not to sell for abroad, even to the allies. The result is, there are no export quotations. As a matter of fact, so scarce is Cleveland pig-iron that deliveries to home customers are having to be curtailed, the already limited quantity allocated to Scotland having been further cut down by about 50 per cent. Notwithstanding this situation, a feeling prevails that prices will not be further advanced. To home customers, No. 1 is 230*s.* and No. 3 and the commoner grades of Cleveland pig-iron are 217*s.* 6*d.*

Hematite Iron.—While hematite iron is perhaps a little less scarce than Cleveland pig-iron, customers complain that they experience great difficulty in placing orders on either home or foreign account. Producers are quite comfortably placed and many of them are disinclined to further commit themselves to any extent. For home consumption, Nos. 1, 2 and 3 East Coast brands are 260*s.* and No. 1 is 262*s.* 6*d.*; and for shipment to France, Belgium and Italy mixed Nos. are 265*s.* and No. 1 is 267*s.* 6*d.*

Foreign Ore.—Inactivity characterises the foreign ore trade. Sellers are inclined to take a rather firmer stand, pointing out that prices of ore at the mines are stiffening, and opining that freights are likely to rise again, but consumers are holding off the market as they have substantial stocks, and large quantities coming forward

against contracts made. The ex-ship Tees value of rubio, of 50 per cent. quality, may be given as in the neighbourhood of 60*s.*

Coke.—Coke is steady, firm, and fairly active, an ample supply now meets the heavy local needs. Average blast-furnace kind is 62*s.* 9*d.* at the ovens, and quality low in phosphorus is 65*s.* 3*d.* at the ovens.

Manufactured Iron and Steel.—Finished iron and steel manufacturers have much more work on hand than they can cope with, but pressure for supply of certain materials is less pronounced, and foreign customers are hesitating to pay the high prices now named. Common iron bars are 30*l.*; marked bars, 32*l.*; rivets, 38*l.*; steel ship, bridge and tank plates, 23*l.* 10*s.*; steel angles, 23*l.*; steel joists, 23*l.*; soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; heavy steel rails, 23*l.*; and fish plates, 28*l.*

Ironworkers' Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England have certified the average net selling price of bars, and angles for the two months ending April 30 last, to have been 25*l.* 8*s.* 0·49*d.*, as against 23*l.* 11*s.* 3·79*d.* for the previous two months. On these figures the sliding scale gives an advance of 20 per cent. on puddling, and other forge and mill wages to take effect from May 31.

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough last month totalled 54,602 tons, as compared with 89,785 tons for April, the falling-off being largely accounted for by the dockers' strike. Of the 31,913 tons of pig-iron cleared in May, 18,426 tons went to foreign ports, and 13,487 tons went coastwise, the largest customers being Scotland, 9,337 tons; Belgium, 6,211 tons; Italy, 5,321 tons; France, 1,936 tons; Holland, 1,910 tons; and Japan, 1,145 tons. Manufactured iron loaded last month amounted to 3,187 tons, 3,112 tons going abroad, and 75 tons coastwise. India, with an import of 2,573 tons, being by far the largest buyer. Of the 19,502 tons of steel shipped in May, 17,668 tons went foreign, and 1,834 tons went coastwise, the largest receivers being India, 7,737 tons; Japan, 2,050 tons; British East Africa, 1,420 tons; and Italy, 1,042 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Business in the steel trade of Scotland continues to show little in the way of change as makers are still not too anxious to book much more forward. The amount of work already in arrears is considerable and the general desire is to get the major portion of it cleared off the books and then to see how things stand. Of course, where buyers are very pressing and are willing to accept the conditions laid down by makers a certain volume of new business is being taken. Supplies of fuel and raw material are not yet any more satisfactory and production is suffering in consequence, but makers are distributing the output to the best of their ability. Consumers keep pressing for supplies with the evident feeling that if they did not do so they might be somewhat forgotten. The demand for ship plates is very strong, and the enormous quantity used on the Clyde alone during the past two months shows clearly that the recent output from the local steel works has been on a very large scale. The same may be said of boiler plates and makers are still very busy in this department. For sectional material there is likewise an excellent demand, and everything turned out is quickly taken up. Black sheet makers have no difficulty in disposing of their output which is all earmarked a long way ahead and consumers keep pressing for deliveries to enable them to carry on. Home trade is taking up the great bulk of all steel being manufactured at present, and there is still little left over for export. Prices are strong and unchanged, and there is little prospect of any easing-off meantime.

Malleable Iron Trade.—Active conditions are general in the West of Scotland malleable iron trade and deliveries are anxiously awaited by local consumers who are still receiving the bulk of the make. Order books are very full, and even with "crown" bars round 28*l.* per ton there is lots of business on the market.

Scotch Pig-Iron Trade.—The strength of the demand for all grades of Scotch pig-iron is unabated, and the scarcity continues. Hematite is being consumed at a great pace in the local steel works, and there is great pressure for delivery. Foundry iron is also in great request, and everything offered is quickly taken up by home users, and little or nothing is left over for export. Prices are unchanged officially over the week, and are from 13*l.* 10*s.* to 14*l.* per ton for No. 1 grade.

Scotch Shipbuilding.—The Scotch shipbuilding returns which have just been issued for the past month are extremely satisfactory and amount to the total of 27 vessels of 64,832 tons, as against 34 vessels of 102,468 tons for the previous month. In the April figures the output from each of the different centres of Scotland was much larger, but they were all considerably above the average monthly return for the year. The figures for the past month are as follow:—

	Vessels.	Tons.
The Clyde	23	61,735
The Forth	1	2,500
The Tay	1	88
The Dee and Moray Firth	2	509
Total	27	64,832

Interest attaches to the Clyde figures because they are the second largest for the year to date, and because they have only twice been bettered during any previous month of May—in 1907 when the total was 40 vessels of 62,246 tons, and in 1911 when the total was 28 vessels of 93,846 tons. When everything is taken into account, labour troubles of one sort and another, short deliveries of plates, &c., as well as of other commodities, the output for the past month, as well as for the year to date, is exceedingly good. The five months' total is now 76 vessels of 244,697 tons, which is the fourth highest on record, but it is still 49,300 tons behind the large output for the same period of 1913. There is thus a lot of leeway to make up, but if supplies of material could only be increased a new record output for the Clyde might yet be put up. There is an abundance of orders on hand, and although there are pessimists who say that our time of quietness is assuredly coming, it is no use to look forward to such an eventuality at present, but may just go ahead as fast as possible, hoping for the best. Fresh bookings have not been heavy of late.

Wages in the Iron Trade Increased.—Mr. John M. MacLeod, C.A., Glasgow, has made the following intimation to Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board: "In terms of the remit I have examined the employers' books for March and April, 1920, and I certify the average net selling price brought out is 25*l.* 17*s.* 11·4*d.*" This means an increase of 20 per cent. on basis rates.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Some details of the Coal Controller's proposals for the decentralisation of control in the coal trade have been officially communicated to the industry. The change involves a diminution in the scope of departmental control from London and introduces new conditions in the regulation of both inland and export business. The immediate effect of the change will be to increase the quantity available for home consumers, but imposes a further restriction on the amount which will be at the disposal of exporters. In fact, the quantity available for export is to be limited to a fixed quantity of 20,000,000 tons per annum from the United Kingdom as cargo, compared with 73,500,000 tons in 1913, and from South Wales to 13,500,000 tons, against 30,000,000 tons in 1913. Of the exports 45 per cent. are to go to France, 20 per cent. to Italy and the rest is to be divided between other destinations at the discretion of the Coal and Coke Supplies Committees in the different districts, which bodies will presumably be responsible for releases of cargoes. As far as South Wales is concerned the decrease in exports means a reduction of about 48,000 tons per week, as compared with the average weekly shipments this year. The home market will continue to get the quantity with which it has been supplied during the past few weeks, and in addition to this amount about 250,000 tons per month extra, and it will be up to collieries to find buyers for this extra quantity. In this way it is hoped that the increased supply in the home market will result in the re-establishment of the pre-war system of freedom in the normal relations of producers and consumers. The present scale of maximum prices is to remain. The importance of making a success of the new arrangements has been pointed out to the trade, for it is understood that failure in this respect will considerably prolong the ultimate decontrol of the industry in regard to both home and foreign business. Another important event during the past week has been that of the action of the French Government in fixing maximum c.i.f. prices at which British coals may be imported and resold in France. The maximum prices are about 22*s.* per ton less than the current prices, and it seems that France will have to rely on contract quantities for her supplies unless some arrangement is made with our Government in the matter. Operators at present are waiting developments, and for the present only those contract quantities which bring the price of coal and freight combined at or under the maximum schedule are being shipped. Whether France will be able to make the scheme practicable remains to be seen.

The Iron and Steel Trades.—A waiting policy has been adopted by operators during the past week. Buyers on the one hand hold off in the hope of a fall in prices, and sellers were content to wait, as generally they were of the opinion that although there has been a big fall in the price of tin the increase in labour costs, &c., made the chances of any material drop in the price of finished products rather remote, and consequently 69*s.* to 74*s.* was steadily indicated for standard boxes of tin plates. Galvanised sheets were quiet at 55*l.* per ton for 24-gauge corrugateds, while steel bars were unchanged at from 26*l.* to 30*l.*

AGRICULTURAL TRACTOR TRIALS.—The site of the agricultural tractor trials which are being promoted this year by the Royal Agricultural Society and the Society of Motor Manufacturers and Traders has now been selected. The trials will again be held near Lincoln, but about 2 miles further away from the city than last year and close to the village of Scampton, on the road to Burton and Carlton.

"TECHNOS."—The issue of a new publication entitled *Technos* has been commenced at the price of 6 francs per monthly part, by Mr. E. Chiron, 40, Rue de Seine, Paris 6. It gives brief illustrated abstracts in French of articles in French and foreign technical journals. The articles are classified alphabetically under the headings Mines, Metallurgy, Civil and Mechanical Engineering, Electricity, &c. The first issue, for April, has 95 pages printed on one side of the page only, for cutting out and classifying. The publication appears to be well got up and will prove useful for reference purposes.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—Monday evening, June 7, at 8 p.m.: Cantor Lecture, "Aluminium and its Alloys," by Mr. Walter Rosenhain, B.A., D.Sc., F.R.S., Superintendent, Metallurgy Department, National Physical Laboratory. The Third Lecture of the above Course, which was postponed from April 26, in consequence of the sudden illness of the lecturer, will be delivered on the date above named.

THE OPTICAL SOCIETY.—Thursday, June 10, at 7.30 p.m., at the Imperial College of Science and Technology, South Kensington, S.W. 7. The following papers will be read: "Accuracy of Setting," by Miss A. B. Dale; "A New Method of Immersion Refractometry," by Dr. John S. Anderson. A demonstration, showing a quick method of moulding small lenses of sufficient accuracy for low-power eyepieces, &c., will also be given by Mr. A. Wood.

THE INSTITUTION OF MINING ENGINEERS.—Thursday and Friday, June 10 and 11, Meeting in the Rooms of the Geological Society, Burlington House, Piccadilly, London, W. 1. Thursday, June 10, at 11 a.m.: General Meeting in the Rooms of the Geological Society, Burlington House, Piccadilly, London, W. 1. The President will open the meeting. The following papers will be read, or taken as read: (1) "Compensation for Subsidences," by Professor Henry Louis, M.A., D.Sc., A.R.S.M., M.Inst.C.E., F.I.C., F.G.S.; (2) "The Fleissner Singing-flame Lamp," by Mr. William Maurice, F.G.S.; (3) "The Wolf-Pokorny and Wiede Acetylene Safety Lamps," by Mr. William Maurice, F.G.S.; (4) "The 'Oldham' Cap Type Miner's Electric Safety-lamp," by Mr. George Oldham. The following papers, which have already appeared in the Transactions, will be discussed: (a) "First Report of the Committee on 'The Control of Atmospheric Conditions in Hot and Deep Mines,'" vol. lviii, page 231; (b) "A New Method of Working Thick Seams of Coal at Baggeridge Colliery," by Mr. Dudley S. Newey, B.Sc., F.G.S., vol. lviii, page 257; (c) "Protractors," by Mr. T. G. Booking, vol. lviii, page 282; (d) "Magnetic-Meridian Observations: A Method of Utilising the Kew Observatory Records," by Mr. T. G. Booking, vol. lviii, page 289. 1 p.m.: An adjournment will be made for luncheon. 2.30 p.m.: The General Meeting will be resumed. 5 p.m.: The General Meeting will be closed. 7 p.m. for 7.15 p.m. prompt: Dinner at the Connaught Rooms, Great Queen-street, Kingsway, W.C. 2. Friday, June 11, at 10 a.m.: Visit to the Royal School of Mines and the Science Museum (Mechanical Engineering Section), South Kensington, S.W.

THE CONCRETE INSTITUTE.—Thursday, June 10, at 7.30 p.m., at Denison House, 296, Vauxhall Bridge-road, Westminster, S.W. 1, paper by Mr. Edward L. Joseph, on "Ventilation and Air-Purification as Applied to Modern Concrete Buildings."

IRON INDUSTRY OF CHINA.—A summary of the iron ore resources of China, says *The Iron Age*, New York, is given by Mr. Julean Arnold, commercial attaché of the Bureau of Foreign and Domestic Commerce in that country for many years, in a commercial handbook of China which has just been issued by the Bureau. Mr. Arnold says: "Dr. H. Foster Bain, assistant director of the United States Bureau of Mines, who spent some time in China investigating its mineral resources, estimates that China has 400,000,000 tons of iron ore available and suitable for modern furnace reaction, and an additional 300,000,000 tons that might be treated by native methods. The iron ore deposits are now controlled by Chinese or Japanese interests, the Chinese Government aiming to control those that are not already mortgaged to Japanese interests. The Penchihu furnaces were producing in 1918 about 75,000 tons of pig-iron. The Anshanchan Iron Works in Manchuria, operated by the South Manchuria Railway, have an annual output of 150,000 tons. The Han-Yeh-Ping furnaces are probably producing an equal amount, which will be increased when the company's furnaces are in operation at Tayeh. Thus a fair estimate of China's production of pig-iron (1918) would seem to be about 500,000 tons a year."

THE BUCKMAN ENGINEERING CENTRE.—Early in the war Messrs. Buck and Hickman, Limited, organised a training centre in order to familiarise as large a number of men as possible with the features of modern up-to-date machine tools. Soon after its inauguration this was taken over by the Ministry of Munitions, the firm lending the whole establishment and staff to the Government, with the result that over 800 competent operators were trained and supplied to munition centres. The establishment has now been converted into a demonstration department where the latest patterns of machine tools such as millers, grinders, automatics, &c., may be seen at work and where instruction is given in the use of these machines to representatives of customers. At the same time the department is run with a view to being an actual producing plant. The work undertaken is varied, but one of the chief products at the present time is automatic work of a high degree of accuracy, and limit gauges of all descriptions. The department is naturally equipped with the best and most modern machines for precision work, including the latest patterns by Messrs. Brown and Sharpe, Pratt and Whitney, &c., and the accuracy aimed at is exceedingly good, with machine finish only. The testing and inspection of the finished articles is thoroughly organised. The firm are pleased to show visitors at any time over this department, which is situated at No. 3, Adler-street, Whitechapel, E.1. A small illustrated pamphlet describing this centre has lately been published by the firm and gives an illustrated account of their methods.

LATHES WITH ALL-GEARED HEADS.

CONSTRUCTED BY THE CINCINNATI LATHE AND TOOL COMPANY, CINCINNATI, OHIO, U.S.A.

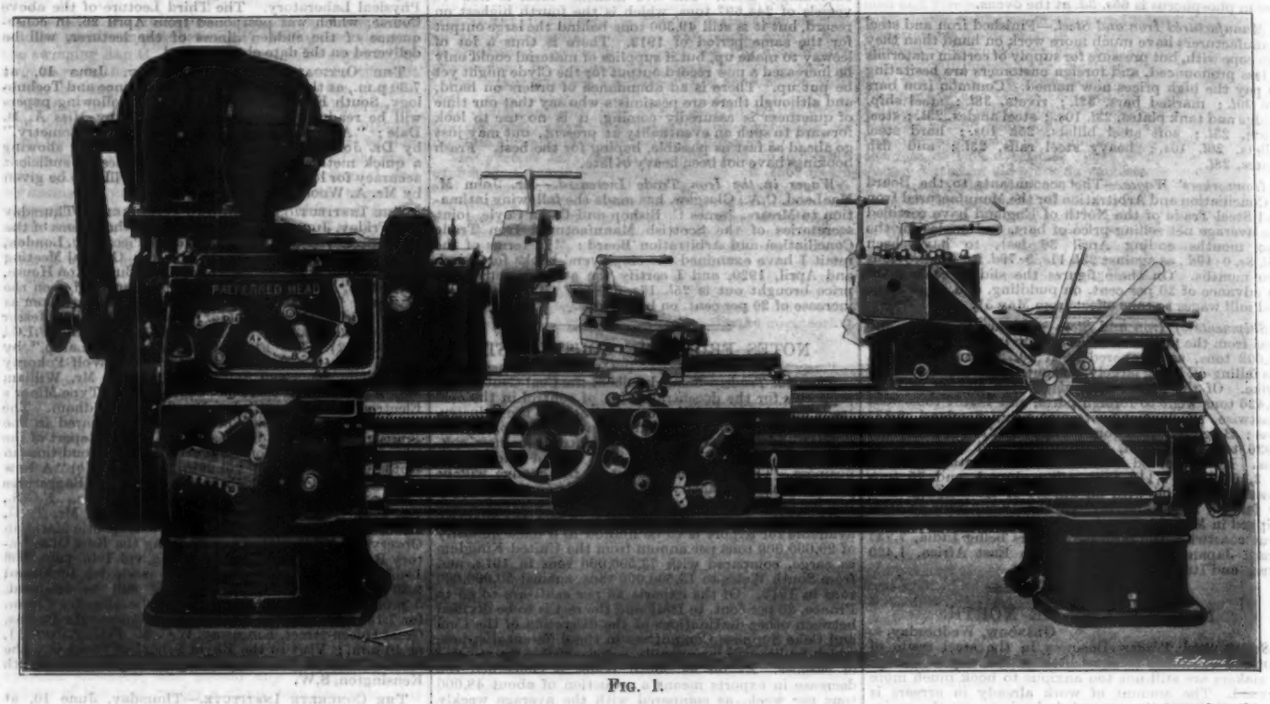


FIG. 1.

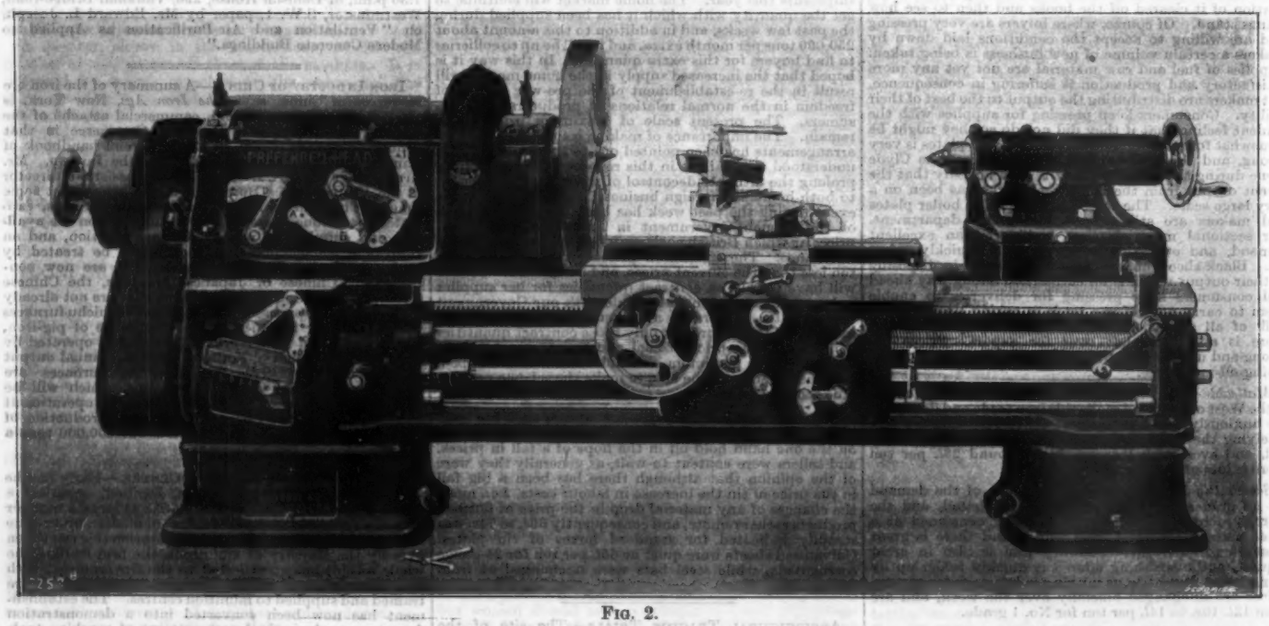


FIG. 2.

Two recent patterns of all-geared head lathes, manufactured by the Cincinnati Lathe and Tool Company, of Oakley, Cincinnati, O., U.S.A., are illustrated above. Both models are made in sizes from 8 in. to 14 in. centres, and are adapted for either single pulley belt drive, or motor drive. The turret lathe, shown in Fig. 1, is, as will be seen, motor driven through a silent chain. As all speed regulation is obtained in the head a constant speed motor is used. The change-gear gives 12 spindle speeds, which are obtained by manipulating the three levers on the front of the headstock. The main spindle is of high carbon steel and carries only the face gear and one direct-driving gear, which is operated by the centre lever, which has two positions, A and B. An intermediate shaft carries three sliding gears, which are controlled by the lever which has three positions marked 1, 2 and 3, in the figure. These gears mesh with the back gear, which has three stationary gears of differing diameter, and a pair of sliding gears. The driving shaft, operated at constant speed, has two sliding gears meshing with gears on the intermediate shaft. When the gear to the left is in mesh with the intermediate shaft gear the first six low-speed changes are given. When the right-hand gears mesh the six higher-speed changes are obtained. Only the gears actually used in driving are in mesh at any time. A neutral position is provided permitting the spindle to be revolved by hand when jobs are being set up.

The various shafts in the head are of high-carbon nickel steel, and the gears on the back shaft and the direct-driving gears are of steel forgings, heat treated. All other gears are of high-carbon nickel steel. The shafts run in bronze bushes. All bearings and gears are lubricated on the splash system from a reservoir in the base of the head. The shaft bearings are kept oiled through grooving in the top cover, to which oil is distributed by the rotating gear wheels. An indicator shows the depth of oil in the reservoir. The arrangement of the power feed drives will be clear from the figure. The front levers control all the feed changes. The turret traverse operates through a belt at the rear end of the lathe as shown. The lathe in Fig. 2 differs from that in Fig. 1 in being fitted with a poppet head for centre work. In view of its similarity to the other machine no description is necessary, but attention may be called to the arrangement of the hand traverse for the poppet head.

MESSRS. CLAYTON AND SHUTTLEWORTH'S WORKS AT LINCOLN; THE STAMP END WORKS.

(*For Description, see Page* 741.)

FIG. 3. BOILER SHOP.

FIG. 4. SAW MILLS.

FIG. 5. OIL ENGINE ERECTING SHOP.

FIG. 6. STEEL FOUNDRY.

MESSRS. CLAYTON AND SHUTTLEWORTH'S WORKS AT LINCOLN; THE STAMP END WORKS.

(*For Description, see Page* 741.)

FIG. 7. OIL ENGINE MACHINE SHOP AND TESTING BAY.

FIG. 8. IRON FOUNDRY.

MESSRS. CLAYTON AND SHUTTLEWORTH'S WORKS AT LINCOLN; THE STAMP END WORKS.

(*For Description, see Page* 741.)

FIG. 9. PRESSES IN BOILER SHOP.

FIG. 10. BOILER SHOP—ERECTING BAY.

MESSRS. CLAYTON AND SHUTTLEWORTH'S WORKS AT LINCOLN; THE TITANIC WORKS.

(*For Description, see Page* 741.)

FIG. 28. VIEW OF MACHINE TOOLS ON GROUND FLOOR.

FIG. 29. GENERAL VIEW OF SHOP FROM GALLERY.

AGENTS FOR "ENGINEERING."

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NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d. post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 757.

ENGINEERING.

FRIDAY, JUNE 4, 1920.

RESEARCH WORKERS.

RESEARCH is in danger of becoming an idol of the market-place. It is now a matter almost worthy of the attention of the daily Press. So much useless compilation of data has in the past been carried on under the name of research, that one fears much of the uninstructed enthusiasm which is now running in its favour may help only to swell the useless total. The central feature of research, if it is to be of any value, is the research worker, and it is much to be hoped that a fair proportion of the work now projected may get into the hands of men not only of learning, but of judgment. There is nothing new about research, and every civilised nation has probably had some research workers since the dawn of history. The professional, employed, research worker is, however, of comparatively recent date, and it is to be feared that much of the valueless so-called research has been done by him, under more or less scholastic auspices.

The extent to which research is now likely to be carried on in this country is perhaps best illustrated by the fact that sixteen Research Associations, formed in connection with the Department of Scientific and Industrial Research, have now been licensed by the Board of Trade, while twenty-six others are in an advanced stage of development. These various bodies must in the aggregate involve a very large staff, and the question of where this staff is to be obtained, and of whom it is to consist, is of great importance. It looks as if the research worker will probably become a member of a definite and large body, like the schoolmaster and the technical college lecturer. Incidentally, we have, we believe, the authority of a committee of the Privy Council for referring to the members of this new body as "researchers." The term, however, is singularly cacophonous, and we will avoid it as long as we may. It is quite possible that it may come into common use, and its introduction further illustrates in what way research work is coming to be looked upon as a peculiar sphere, if not a special profession.

There is clearly danger that research taken up in a sort of wholesale way may lead to a good deal of time being wasted and money spent to no end, but against this one must allow that the mere scale on which the work is to be done increases the possibility of really valuable discoveries. One must hope that the gold will outweigh the dross. We are not concerned just now with the question of "pure" research against research with a definite end in view, but it is allowable to suggest that the practical nature of the work of the various research associations will be to some extent ensured by the fact that they will be to a considerable degree under the control of manufacturing firms. The actual research work of these various associations will presumably be carried on under a director, or directors, who will be chosen in virtue of their personality, their record, and their knowledge of the field which the work of their association is to cover. These men will be comparatively few in number, and must be considered individually. They may be left out of account in a consideration of the supply of research workers generally.

A considerable part of the work inspired and directed by the various associations will doubtless, especially at first, be carried out in existing institutions, educational and otherwise. The outlined programme will, however, demand more accommodation than is available in this way, and new research centres must be started. In addition, considerable extensions to the research work in the laboratories of private firms may be expected. Whatever way the work is carried out, a great increase in the number of workers will be necessary, and the question of the supply of these workers is, as we have already stated, one of importance.

It may naturally be expected that the connection now existing between the college laboratory and research generally will cause the research associations to look to the technical institutions for the men required to build up their staffs. We trust, however, that this procedure will be followed only in moderation and with care. That a research worker will almost as a matter of course be drawn from a technical college appeared to be assumed in a paper read by Mr. J. W. Williamson before a conference of research associations, convened by the Department of Scientific and Industrial Research, which was held in the hall of the Institution of Civil Engineers on the 14th ult. Mr. Williamson, who is secretary of the Scientific Instrument Research Association, was concerned with the attractiveness of research as a career for university trained men, as compared with teaching, &c. Mr. Williamson did not preclude the obtaining of research workers from other spheres, but did not refer to such a possibility and almost appeared to assume as a matter of course that research associations would be staffed by men coming straight from college. We admit that this probably arose from the limited subject of the paper, but we should like to put in a protest against the idea that the wholesale research which is to be carried out should in the main be turned over to raw college men. That, excepting the very unusual man, the main part of research will have to be done by college-trained men is obvious, but we trust it will be possible to leaven the raw men with a large proportion of men who have seen something of commercial and practical life subsequent to their academic training. We have assumed earlier that the directors of research will be something more than mere college men, but much of the value of what is done will depend on members of the staffs other than directors and it is very essential that these members should at least have some of that practical judgment which can with difficulty, or not at all, be obtained inside the walls of a technical institution.

Whatever is done it will be no easy matter to get together a really adequate personnel on a large scale and the collecting of a fair proportion of the total from practical work will be even more difficult than obtaining the remainder from technical colleges. This added difficulty, however, only gives point to Mr. Williamson's paper. If the attractions of a scholastic or college career make it difficult to recruit the best men from the technical schools one may easily imagine that the attractions of commercial life will make it still more difficult to obtain the best men from the sphere of practice, and it is only the best men that are wanted. Mr. Williamson's thesis briefly was that if you want the best men from the colleges you must pay for them and the same solution clearly must be the main lever in obtaining men from commerce. The question of security of tenure also comes in, however, and in a very definite way since the Government guarantee to the research associations is at present limited to five years. This is bound to be a handicap in getting a staff together. The man fresh from college may be prepared to risk things for the sake of getting a start and obtaining experience, but the really good man employed by a private firm is bound to consider this question seriously before he can be attracted to a research association.

On the question of salary, Mr. Williamson pointed out that the cost of living for the class of

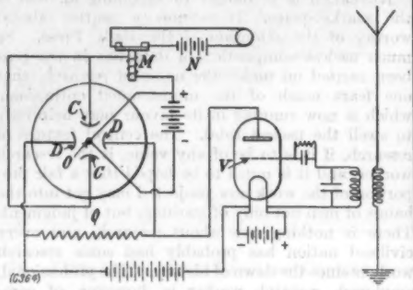
society from which research workers were drawn had risen at least 130 per cent. above pre-war standard. He continued that it was "useless to offer salaries of 230*l.* to 350*l.* a year with very indefinite prospects of advancement and with no security of tenure beyond the five years period." Mr. Williamson would make the initial salary of "an ordinary member of the research staff" 400*l.* a year. This would be the minimum. Workers of longer experience or special qualifications would, of course, be paid more. The arguments for this minimum were reinforced by reference to the yearly sum now earned by unskilled or low-skilled labour, and there is no doubt but that Mr. Williamson was in this matter voicing the opinions of a very large number of people. The relative values of brain and muscle in the market have now become absurd. The present state of affairs is not only unfair to the brain worker, but is radically unsound. It is a much easier job to paint a lamp-post than to investigate the vagaries of the cast-iron of which that post is composed, and if the former job is going to be better paid, there must and will grow up a decreasing tendency for anyone to tackle the latter. Unless brainwork is properly paid there will sooner or later be a lack of brain-workers. It is much to be hoped that the research associations may set a fashion in the payment of adequate salaries for the class of work done.

Finally, in connection with the matter of security of tenure we should say that Mr. Williamson proposed that research workers should be brought within the Federated Superannuation System for Universities. This would enable a research worker moving from one research association to another or from a research association to a university to carry any accrued superannuation benefits with him. Further, if this research association movement is to be taken seriously one cannot contemplate it terminating in five years. In Mr. Williamson's words "to make no effort towards the establishment of a definite scheme of superannuation is not merely to abandon the attempt to compete on level terms for the trained researchers needed, it is to stamp the whole research movement embodied in the research associations as ephemeral and to proclaim the little faith of those responsible for their direction."

THE THERMOIONIC VALVE AND TELEPHONY.

INFORMATION concerning the thermoionic valve, officially withheld during the war, which favoured its development, has been so freely published of late that we have to restrict ourselves in our notice of the brilliant discourse on "The Thermoionic Valve in Wireless Telegraphy and Telephony," which Professor J. A. Fleming, F.R.S., delivered at the Royal Institution on May 21. We regret the necessity, since Dr. Fleming is one of the fathers of the thermoionic valve. Historically, the matter goes back to the early days of the electric glow lamp. Placing, in 1883, a metallic plate near the incandescent loop, Edison observed that a current was flowing, from loop to plate, when the plate was joined by an external wire to the positive (not the negative) lamp terminal. Dr. Fleming then found that the Edison effect was stopped when a mica screen was interposed between loop and plate, and that the current would discharge a positively-charged conductor. Though some of these effects were also studied by Hittorf, before 1888, and though J. J. Thomson's discovery of the corpuscular character of the electrons fell within the last years of the past century when electric radiations caused so many sensations, nobody attempted to utilise the thermoionic current, before Dr. Fleming, in 1904, proved that his valve—simply a highly-evacuated lamp, the filament of which was surrounded by a metal cylinder—would rectify the electric oscillations of radiotelegraphy and could thus serve as a detector, in addition to the coherer, the magnetic-wire, and the electrolytic detectors then in use, which it has now almost superseded. The next great improvement of the valve was due to Dr. Lee de Forest who, in 1907, placed a grid electrode between the filament and the cylinder or plate, and thus converted the diode into a triode—terms which Dr. Fleming did not use, by the way.

We have explained on other occasions, how the grid, by being itself electrified, helps to amplify the arriving oscillations on the relay principle, the energy being taken from the battery in circuit. When we pass the plate current of valve I through the primary of a transformer, and join the secondary of this to the grid and filament of a second valve, we amplify the current variations in the second valve, and when we connect *n* valves in series (cascade), each magnifying 10 times, we magnify the original oscillations 10^n times. The ordinary radiotelegraphy sets of the Marconi Company, which Dr. Fleming exhibited, contain seven valves, six serving as amplifiers, the seventh as rectifier. But the valve can also be utilised as a power valve, to generate electric oscillations, and that is very important, since it enables us to dispense with high-frequency alternators. For this purpose the one terminal of the battery is, though a coil, connected to the grid, a condenser and the filament, the latter being with its own small battery in shunt to this circuit; the other terminal is joined, through a second coil, to the plate, and the two coils are inductively coupled. The two circuits then control one another after the manner of the piston and the slide valve of a steam engine, and Dr. Fleming further illustrated the action with the aid of the "singing telephone." In this apparatus, which comprises a battery, the diaphragms of the microphone and of the receiver are of the same size; nobody was speaking into the transmitter, and no



sound was heard, until Dr. Fleming held the transmitter mouthpiece over the receiver mouth; then a shrill note sounded. The source of the sound was supplied by the small noises in the room which varied the microphone resistances, and microphone and receiver reacted upon one another.

In radiotelephony we transfer the undamped oscillations, produced by an alternator or by a power valve, by induction to the tuned aerial; the amplitude of the radiated waves is varied by the speaking microphone through the intermediation of a control valve, the grid of this latter valve being inductively connected by a transformer with the telephone transmitter and its battery. The grid potential thus varies in accordance with the sound waves, and the plate circuit, which is in parallel to that of the power valve, modulates the amplitude of the aerial currents. The Marconi set which the lecturer exhibited requires 0·25 kw. for a range of 200 miles. For aircraft telephony the potential is produced by a small high-tension dynamo driven by a wind motor, the other energy being taken from storage cells. The aerial is a wire, 250 ft. long unwound from a drum as required, or simply a frame wound with a few turns of wire. To shut off the noise of the machine, the pilot wears a helmet, the ear and mouth-pieces of which, once carefully adjusted, are automatically fixed.

Dr. Fleming also mentioned the experiments conducted in March, 1919, by the Marconi Company to determine the minimum power required for effective radiotelephony across 1,800 miles of the Atlantic, from County Kerry to Cape Breton. An alternator of 2·5 kw., of 12,000 volts, rectified by a Fleming valve, an umbrella aerial supported on masts, 500 ft. high, waves of 3,800 m. and seven valves in the receiver were used. The transmission was good, but a little more power, such as six power valves would yield, seemed desirable for a regular service.

The call bell, indispensable for such transmission, must be very sensitive and must yet not respond to every passing signal. The Marconi Company uses for this purpose a magnetic-needle relay which is not closed by one impulse, but which is actuated by a series of 180 successive dots per minute. Dr. Fleming's bell and four-anode valve and its connections are illustrated in the annexed diagram. The filament O (seen endways) is surrounded by two pairs of curved metal plates, the collecting plates C (joined through a relay M with battery N to the + pole of the filament battery), and the deflecting or potential plates D, joined through a resistance Q of 20,000 ohms to the plate circuit of the triode valve V, the potential of which deflects the electrons (emitted by O) so that they cannot reach C and energise the relay. When, however, the grid of V is given a (very small) negative potential—which is derived from the oscillations in the aerial—the thermoionic current of V is decreased, that of O is increased, and the relay is closed.

We pass over Dr. Fleming's demonstrations of heterodyne reception of radiotelephone waves to his concluding remarks on the insertion of valve-repeaters in ordinary telephone lines for the sake of economising copper. On the London-Glasgow trunk telephone line the stout copper wire weighs 1,600 lb. per mile, and the total copper weight for the 400 miles of double line amounts to nearly 300 tons. The longer the line, the stouter must be the wire. The difficulty with repeaters is that the line has to be used in both directions, and that, in the amplifier inserted, the plate current might react on its own grid and set up a howl in the receiving telephone. Edison devised a connection which avoided this, if placed just in the electric centre of the line. As this is not generally possible, the British General Post Office balances the two sections against artificial lines, and the two valves of their duplex system double the range of line. The system was demonstrated after the lecture. In a similar way, Dr. Fleming added, the double telephone line New York–San Francisco, 3,400 miles long, was worked with three valve-repeaters, and if the British telephone trunks had to be relaid, a great economy in copper could be realised by a widespread use of thermoionic valves.

The Marconi-Osram Company exhibited, in connection with the discourse, a fine collection of valves of all sizes, up to 1 ft. in length. The valve-filaments are all made of tungsten; the other metal parts may be of molybdenum—less brittle, though hardly less expensive than tungsten—and nickel.

ABSORPTION GASOLINE.

IN a recent article we stated that in 1917 about 218,000,000 gallons of gasoline were recovered from natural gas. To be strictly accurate the figure recorded was 217,884,104 gallons. This is a wonderful development over the 7,500,000 gallons produced only six years previously. The figure is interesting from another point of view. In the earlier years practically the whole was the product of the compression or vacuum processes of treatment. Latterly, however, a marked change has come over the industry and another process known as the absorption process has been introduced which bids fair to rival those of earlier date. The output by this process is already established on a large scale, and the product appears to be of a good deal better quality. The method is more easily adapted to natural gas of different qualities.

The process is based on the fact that liquids absorb gases with which they are in contact in a definite proportion dependent upon the pressure. Briefly the natural gas under pressure is brought into contact with an absorbing medium, the latter being subsequently treated by distillation for the recovery of the gasoline constituents. Before describing the process in detail it will perhaps serve to make matters clearer if we take a typical plant and run through it. Firstly, then, the gas from the walls, either under a suitable pressure direct from the casing head, or raised to a suitable pressure by pumping, is admitted near the base into an absorption tower. In this tower is a stream of oil flowing from a height to the bottom. The gas rises through the oil, giving up its gasoline constituents to it, and issues from the top of the tower into the pressure pipe line. The oil is run off at the bottom and taken to a weathering tank, from which it is drawn off by a low-pressure pump and passed

through a heat exchanger to a still. In passing through the heat exchanger it absorbs heat from the oil issuing from the still. The latter passes through a high-pressure pump and cooling coils, and is again delivered to the absorption towers, while the vapours driven off in the still are condensed. The water is separated from this distillate, and there remains the gasoline product.

The types of gas which may be treated satisfactorily by this system vary from very lean or "dry" gas up to quite rich gas. In this the process has the advantage over the compression system. In the latter it is stated that gas yielding less than three-quarters of a gallon per 1,000 cub. ft. cannot be profitably treated, whereas the absorption process is successfully employed with gas giving only one pint or so of gasoline per 1,000 cub. ft., and is employed in the Eastern States for treating high-pressure "dry" gas from wells yielding no oil.

In the gradual development of the process the type of absorber has undergone some change. Originally an horizontal design was favoured, but at present a vertical tower pattern is more popular. The design of these varies to suit the gas treated. Generally speaking, lean gases are treated at high pressure and rich gases at comparatively low pressure. Towers for the former, therefore, are kept to comparatively small diameters, while for the latter larger diameter towers constructed of boiler plate are sometimes adopted. Generally, however, it is preferred, rather than go to the largest practicable diameters at any particular pressure, to have a battery of smaller towers. The working is more efficient and the advantages are considerable in the event of a failure, only a section of the plant being disabled instead of the whole. For pressures of 200 lb. to 275 lb. per square inch the size adopted will run to from 20 in. to 30 in. in diameter, while the height will be from 25 ft. to 35 ft. There is a tendency for height to increase, with a view to gaining a higher percentage of absorption, due to greater length of contact between the gas and the absorption medium, and the possibility of improving baffling. Towers of the size mentioned above will deal with about 7,000,000 cub. ft. of gas daily.

The towers are furnished inside with a frame or stool, which supports baffling material, keeping it some 2 ft. to 5 ft. off the bottom. Baffling material of many types has been tried, without apparently any decidedly conclusive results. Wood gratings and stone filling are among the cruder types, while in other plants porcelain blocks and tiles, hollow building tiles, steel turnings and other materials are being tried. The deciding factor in baffling is the constriction of the passage, and the critical velocity of the gas through the tower. If passing through the oil at too high a velocity some of the oil is carried out of the towers. It is found that from 30 ft. to 75 ft. per minute is about the proper range. At constricted points the velocity will be above this, but if it rises to 200 ft. per minute the absorption is found to fall off considerably. At the lower velocities the gas and oil are in contact in towers of the common proportions for about 50 seconds. Any increase in height of the tower results in a direct increase of this useful period. In some instances in order to increase the absorption the gas is passed through two or more towers in succession, but this plan does not seem to be often adopted. In a few cases bubbling the gas up through the oil has been tried, but the exposed surface is small, and the effect unsatisfactory. The absorption medium is admitted to the tower some height from the base, sometimes in the form of a spray, and falls over the baffles to the bottom, absorbing on its way the gasoline constituents from the gas. The medium is drawn off from the bottom, and the stripped gas from the top of the tower.

The absorption medium employed is oil, but the class of oil chosen varies over a very wide range from California crude oil (19 deg. B.) to light yellow mineral seal oil of 38 deg. B. Points to be taken account of in this choice are the vapour tension, initial boiling-point and viscosity. On the first depends the capacity of the oil to absorb the light fractions which it is desired to recover; on the second the possibility of securing the desired quality of distillates at the end of the recovery process; on the third the power required for pumping, and the ability of the oil to spread satisfactorily over the baffles. A good oil would be one with a flash-point of about 247 deg. F.; fire test, 262 deg. F.; gravity 37 deg. B.; end point, 695 deg. F.; and viscosity, 1·6 E.D. at 20 deg. C. If a suitable oil be selected there will be a range of about 100 deg. F. between the initial boiling-point of the absorbent, and the end point of the gasoline recovered by distillation; this enables the distillation process to be performed without carrying over fractions of absorbent with the distillate.

From the tower the absorbent passes through an automatic trap to the weathering tank. This is kept at low pressure (2 lb. to 40 lb., according to the pressure of the tower). The reduction of pressure at this stage allows the very light vapours to pass out of the oil, leaving the marketable gasoline still absorbed. The absorbent is then passed by a low-pressure pump to the heat exchanger. Here, on its way to the still, it absorbs heat in a counter-current system from the hot oil leaving the still. As the two differ in quantity only by some 6 per cent. or 7 per cent., the heat transfer may be so effectively performed as to bring the oil going to the still up to within 40 deg. F. of the still temperature itself.

The types of interchangers or exchangers used are of various forms. Some are of the vertical or horizontal barrel type containing a number of tubes, but a form that seems to be very popular is one consisting of concentric pipes. In these continuous coils are made of, say, 3-in. pipe, jacketted on the straight lengths by 6-in. pipe coupled together. The oil to the still passes through the inner pipe, and that coming from the still through the larger series of pipes. The area provided seems to be about 3½ sq. ft. per gallon, per hour, of oil passing through the coils, and the heat transfer seems to run to about 8 British thermal units per square foot, per hour per degree of mean difference in temperature.

The best form of still employed consists essentially of a large shell containing four flat and shallow trays, slightly inclined longitudinally in opposite directions. In each of these trays is a steam heating coil. The absorbent is admitted to the upper tray and comes in contact with the heating coil. It then passes over the end of this to the second, and thence to the third and the fourth, being in each case in intimate contact with the coils. At the bottom of the still is a perforated steam pipe which is kept covered by the oil. The steam discharged from this carries off the last gasoline vapours from the oil. The oil discharged, as already stated, is taken through the heat exchanger, where it gives up its heat to the incoming absorbent. A still of this type, 16 ft. long and 5 ft. in diameter, will deal with 5,000 gallons per hour, using steam at 90 lb. pressure. It takes about 20 minutes for oil to pass through this still. Fire-heated stills are not recommended as the temperature is difficult to control.

The vapour is carried to cooling coils which are of several types, such as submerged, or double pipe, or in louvre towers. The latter seem to be very effective, especially in hot dry climates where evaporation is large. Temperatures 40 deg. F. below atmospheric temperature are obtained in summer. The louvre tower usually contains coils of pipe over which water drips, or the water is cooled in the tower and then used in connection with submerged coils. Water is separated from the condensate, the gasoline product remaining. The absorption oil leaving the heat interchanger is further cooled and sent back to do duty in the towers. This oil takes about 4 hours to do a complete circuit of the plant.

The amount of saturation obtained varies with the working pressure and character of the gas. Tests show saturation over 6 per cent., equivalent to a recovery of a quarter of a gallon per 1,000 cub. ft., though occasional plants show records of 3 gallons to 4 gallons per 1,000 cub. ft. The resulting gasoline has a high gravity (70 deg. to 85 deg. B.) and low vapour tension. It commands in the market a higher figure than the compression product, and is largely used for blending with the heavy fractions obtained as gasoline from the distillation of crude oils.

THE ARRANGEMENT OF ATOMS IN CRYSTALS.

Two noteworthy contributions to our knowledge of crystal structure and its exploration by X-rays were made on Friday, May 28. In the afternoon, Sir W. H. Bragg opened a discussion on the subject before the Physical Society; an abstract of that discussion will appear in due course. The same evening his son, Professor W. L. Bragg, of Manchester University, associated with his father as one of the pioneers of this science, discoursed on "The Arrangement of Atoms in Crystals" before the Royal Institution, giving expression—for the first time, we believe—to considerations which link the views of Sohncke and Groth, developed in the valency-volume theory of close packing of Barlow and Pope, with the most recent speculations of Langmuir on atomic structure and the nature of chemical combination. The engineer is so often advised to consider the simpler case of gases when he inquires about fundamental problems of solids, that he will welcome any new bridge which will help him to cross from the one class of phenomena over to the other.

We may imagine the atoms of crystals to lie on parallel planes at definite, constant, distances d apart. In regular crystals of the rock salt type the planes may be cubical faces or diagonal planes; in more complex crystals a great variety of planes is possible. The X-ray apparatus can only measure angles, and it is the symmetry and the knowledge of the volume and the density of the crystal which enable us to assign distinct values to the several d. In rock salt NaCl, each Na atom is surrounded by 6 Cl atoms (and *vice versa*), and not linked to any particular atom more than the others; several groupings of this kind are possible. In ruby Al_2O_3 the Al atoms probably lie at the ends of the polar axis and the O atoms are symmetrically arranged in the equatorial plane; the symmetry is compatible with any parameters (length of axes), and these we can only determine by X-ray examination.

If we divide the unit cube of pyrites FeS_2 into 8 smaller cubes, there will be 4 Fe atoms at four of the eight corners; the S might either lie in the centres of the cubes or at another spot on the diagonals; X-ray study tells us that each S is near an Fe, at 0·22 of the length of the diagonal. Over 200 crystals have been studied by X-rays; when the structure is complex, the symmetry affords little help as to the d. To go further, Professor Bragg imagines the atoms as in close packing to be expanded into spheres and each sphere to be held in place by touching other spheres; and he shows that, within certain limits, it is then possible to assign to the sphere representing an atom a constant diameter characteristic of the respective element. The distance between the centres of two spheres may then be expressed as the sum of the two radii. The molecular volume of a compound is, of course, far from being equal to the sum of the molecular volumes of the constituent elements; but for the distances an addition law does hold approximately. The apparent variations in the contribution of any element to the molecular volumes of any of its compounds, Professor Bragg explains by differences in crystal structure, and not by variations in the space occupied by the atom. We may perhaps think of "spheres of influence" rather than of actual spheres; the atoms need not really be spherical. But Mr. Bragg assumes that two atoms cannot be placed closer together than at a distance equal to the sum of the radii of the spheres representing them, and he speaks, for brevity sake, of the "atom diameter," meaning "the sphere diameter." He measures them in Angström units (1 A.U. = 10^{-8} cm.).

How is this worked out? We have indicated the crystal structure of the face-centred cubic lattice of pyrites. Metallic iron itself is cubical (Hull), and the distance between two neighbouring iron atoms Fe is 2·47 A.U. If we accept that figure as the diameter of the Fe sphere, the diameter of the sulphur sphere S, fixed as mentioned, will have to be 2·05 A.U. In zinc blende ZnS the distance between the centres of the Zn and S atoms is 2·35 A.U.; if S = 2·05, Zn must be 2·65 A.U. In zinc oxide ZnO, as in blende, each of the 4 O is surrounded by 4 Zn, but the arrangement is hexagonal, the distance

between neighbouring Zn and O atoms is 1·97, and the oxygen atom seems to occupy a smaller space than the S atom, viz., 1·30 A.U. Thus the substitution of O for S decreases the distances between atomic centres by 0·38 A.U., and the same difference is again found for magnesium oxide and sulphide, and for the corresponding compounds of calcium, barium, strontium, the decreases ranging from 0·43 down to 0·36. When we take the fluorine, chlorine, bromine and iodine compounds of the alkalis, we observe similar approximately constant differences. In NaF the distance Na — F is 2·39 A.U., in KF the distance K — F is 2·73 A.U., an increase of 0·41 unit; for the chlorine compounds the difference is 0·17 (ranging from 0·17 to 0·14), for the bromine compounds it is about 0·25 unit, &c. In the crystallised carbonates (which all resemble calcite) the distance between O and C is 1·47 A.U., in diamond the distance between two C atoms is 1·45, and if the oxygen diameter be 1·30, the distance O — C should be 1·42 A.U. From the study of other carbonates it follows indirectly that the diameter of the iron sphere should be 2·74, whilst the pyrites yielded the value 2·47 A.U.; the agreement is not close, in this instance.

In general, however, there is fair agreement, and from X-ray examination and from the crystallographic studies of various authorities, Professor Bragg deduces a new diagram of the "atomic domain." His ordinates are atomic diameters in A.U., his abscissæ atomic numbers. The diagram strongly resembles the Lothar Meyer curve of atomic volumes (atomic weight divided by specific weight), but it refers to compounds as well as to the elements, and to atomic numbers (at N), and the rare elements (unknown to Lothar Meyer) appear strangely significant in the curve. The curve is made up of a series of curves, each corresponding to one of the periods. Each begins with one of the electropositive monovalent alkali metals in the order lithium, sodium, potassium, rubidium, cæsium (to which the greatest diameter is assigned), to descend to elements of higher valency and to electro-negative elements of limiting diameters, and to end with one of the inert gases in the sequence helium, neon, argon, krypton, xenon, niton. In the first period, lying between helium and neon (1·30 A. U.), the sequence is Na, Mg, Al, Si, S, Cl., *e.g.* Professor Bragg finds the clue to these peculiarities in the atomic structure of G. N. Lewis and Langmuir. In the atom of Bohr and others, the electrons rotate in rings round their positive nucleus. Langmuir's electrons can only oscillate about fixed positions, and are distributed in a series of shells, the arrangement being very stable in the inert gases. Helium (at N. 2) has a positive nuclear charge 2, and the one shell contains two electrons; the neon atom (at N. 10) is surrounded by an inner shell of two electrons and an outer shell of eight electrons, making 10 together. Argon (at N. 18) has three shells of 2, 8, 8, electrons, krypton (at N. 36) four shells of 2, 8, 8, 18 electrons, xenon (at N. 54) five shells of 2, 8, 8, 18, 18 electrons. The chemical properties of the elements depend, according to Langmuir, upon the tendency of the atom to surround itself with more stable shells and to revert to the inert gas type, the electropositive atom, by giving up an electron, the electronegative by taking up an electron. In a compound like potassium chloride KCl, the K (at N. 19) has 19 electrons, one more than argon (18); the Cl has 17 electrons, one less than argon. When the two atoms combine, the Cl absorbs one electron and thus acquires one negative charge, whilst the K, by losing the one electron, acquires unit positive charge, and the two stable argon shells are held together by electrostatic attraction. In the crystal the K and Cl are all equally linked, each K to 6 Cl and *vice versa*, and there are no individual molecules. The calcium sulphide Ca S_2 consists of Ca (at N. 20) and 2 S (at N. 16). The Ca loses two electrons; the S gains two. The attractive forces are twice as large as in KCl, and the crystal dimensions shrink consequently. The case of diamond is different. Each carbon atom has a nuclear charge 6, and one inner shell of two electrons and one outer of four electrons. The total number of electrons is thus smaller than in neon (8), and the arrangement is stabilised by each atom of a pair sharing two electrons with its fellow. As every C atom is equally surrounded by four others, the whole diamond crystal shows uniform great hardness in all directions, whilst in graphite Debye and Sherrer found a special arrangement in one plane, which is the cleavage plane.

All electro-negative atoms have small diameters, and in compounds like CO_2 both the atoms contain fewer electrons than would correspond to a stable system. They complete the required number of electrons in their outer shells by holding electrons in common. The electrons of electro-negative elements are fixed by being shared. In crystals of electropositive metallic elements (like K) there are additional electrons, one or several (according to the valency) more than the respective stable system, and these electrons seem to be free, capable of moving under electromotive force. That may account both for the electric conductivity and the ductility of metals. But there are difficulties with metals. That large diameters are assigned to their atoms does not imply a corresponding difference in the dimensions of the atomic structure. The large diameters are rather expressions of the fact that the electro-positive atom does not share electrons with neighbouring atoms, being always surrounded by a complete stable shell. The repulsion between the shells of neighbouring atoms leads to an apparent occupation of larger space. Yet some metals do not concord to the close-packing rule, and many features remain, of course, obscure. All the same one will not simply reject these exceedingly suggestive views, though they may appear both too simple and too arbitrary. They look most fruitful with respect to the valency problems, for instance. It might at once be objected that Langmuir's atom is incompatible with the complexity of the spectra, but these objections have been met by Langmuir, Parson and Stark, and Professor Bragg's researches throw new light on the general problems.

NOTES.

Inland Waterways.

THE Minister of Transport has appointed a Committee to consider and report on the question of the canals and inland waterways of the country. Of this committee Mr. Neville Chamberlain, M.P., has been appointed Chairman, while the other members consist of Mr. W. M. Acworth, Mr. R. B. Dunwoody, Sir J. E. Eaglesome, Sir Noel T. Kershaw, Mr. C. F. H. Leslie, and Sir H. J. Mackinder, M.P. Mr. Arthur Sharp, Development Department, Ministry of Transport, has been appointed Secretary. Mr. N. Chamberlain and other members of this committee have long been associated with endeavours to revive the canal system of this country. The committee includes users, but can hardly be said to be representative as regards the engineering side of the case. It is appointed with the object apparently of providing grounds for the development of a definite policy regarding canals, by the Ministry of Transport. The creation of this Ministry has, of course, altered the position considerably since the issue of the well-known report of the Royal Commission. The terms of reference include the question of acquisition by the Ministry of Transport of Canals, with a view to their improvement, and the terms on which they might be taken over. The form of ownership is to be considered, whether this should be through the Ministry, or regional trusts. The question of costs of improvements, and how these costs are to be met, is to be reported on, as is also the value of frontages. Co-operation between road, rail and water transport is also to be considered. It will thus be seen that the task before the committee is no light one, and it will probably be found that to evolve practicable proposals in regard to these varied points will tax the ability of the members to the utmost.

National Physical Laboratory.

By invitation of the director, Sir J. E. Petavel, a number of representatives of the technical societies, government departments, motor car and aviation industries, and other interested parties, paid an informal visit, on Friday last, to the engineering and aeronautical departments of the National Physical Laboratory at Teddington. Exhibits and demonstrations of the plant and apparatus used in both departments had been arranged to interest the visitors, who were conducted round by members of the laboratory staff. Our readers are doubtless familiar with most of the plant in the engineering department, but we noticed some high-speed testing machines of the Wöhler type which have recently been constructed at the laboratory for studying the reversals of bending stress and complex stress distribution. A hydraulic dynamometer, designed and constructed for use in connection with the forthcoming trials of agricultural tractors by the Royal Agricultural Society, was also exhibited, and another item which attracted considerable notice was the means devised during the war for rapidly inflating the flotation bags of seaplanes. For this purpose a jet of air from a steel gas bottle is directed into a conical mouthpiece in connection with the bag, so that the stream of air draws in with it a large volume of air from the atmosphere. Using only 3 cub. ft. of air from the bottle a bag with a capacity of 46 cub. ft. was fully inflated in 7 seconds. The new buildings for the aerodynamics department are completed and in occupation, and experimental work is being carried on in the 4-ft. and 7-ft. wind channels. Progress is also being made in the construction of the new duplex channel, which consists of two 7-ft. channels placed side by side and combined into one, but a few months will still be required for its completion. It is proposed to hold these informal visits to separate departments of the laboratory at intervals in future, in order to give persons likely to be interested an opportunity to make themselves familiar with the work in progress. The idea, which we believe is due to the director himself, appears to us to be an excellent one, as now that the need for secrecy, imposed by the war, has passed, it appears highly desirable to make the work of the laboratory as widely known as possible—at least to those members of the community to whom the knowledge is likely to be useful. The visits were inaugurated a few weeks ago by a similar function held in connection with the metallurgical department.

LITERATURE.

Elements of Vector Algebra. By L. SILBERSTEIN, Ph.D., Lecturer in Natural Philosophy at the University of Rome. With diagrams. London: Longmans, Green and Co., 1919. [Price 5*s.* net.]

THE author is well-known as an earnest advocate for the employment of vector notation in the mathematical analysis of physical problems, and this little book owes its origin to the application of the method to problems in geometrical optics. In the hands of a master the notation has yielded valuable results in many directions, and the author in his "Simplified Method of Tracing Rays through System of Lenses," has demonstrated its convenience and its merits as a tool for analysis. Apparently some have found that the simplified method needed some further elucidation, and at the instance of Messrs. Hilger, Dr. Silberstein has prepared this supplementary volume, and recommends it as containing "what is required for the purpose of reading and handling" the optical work mentioned. It is claimed to be generally a synoptical presentation of the elements of vector algebra, covering the needs of those engaged in geometrical optics, but so far as we are able to judge, though it may assist any one to follow the reasoning step by step, it will not enable him to use the method in original research by affording a more thorough grasp of the whole problem. We should have liked to have seen the method submitted to two tests, one demonstrating that a result can be reached with less mental effort, or a keener appreciation of the principles involved, or manifesting in some way a distinct improvement over the methods more commonly used. The second is purely arithmetical: it would have been instructive to have seen an example worked out in the manner the author intended, and compared with trigonometrical processes applied to the same problem. The arrangement of work for the computer is by no means an unimportant or an unworthy task, and we had hoped that the author in furnishing what is practically an appendix, would have taken the opportunity of giving to his ana-

lytical expressions the form that would have been best adapted for calculation and ensured the greatest numerical accuracy.

The author may be congratulated on the amount of matter he has collected into a small space, and the completeness of the outline he has presented. He has contrived also to give to this elementary summary an additional interest by deriving some familiar formulæ usually deduced differently. The addition and subtraction of vectors are adequately explained, as is also the scalar product of two vectors. In this latter section appropriate formulæ are applied for deriving the expression for the cosine of an angle in a spherical triangle. The ingenuity of the student is invited to display itself in deriving from vector equality and vector addition the solution of such Euclidean problems as the mutual bisection of the diagonals of a parallelogram and the common intersection of the three medians of a triangle. In the section on the expansion of vector formulæ, the proof of the "sine formulæ" of spherical trigonometry is rather unexpectedly given as an illustration of the adaptability of the method. The derivation of the expression for the product of the sine of a side by the cosine of an adjacent angle is apparently one of those problems that is left to the "care of the reader."

The section on the Linear Vector Operator is the most important in the volume, but is, we submit, too compressed, and the student approaching the subject with no more information than is provided in the previous pages will have some difficulty in following the successive steps. Dyads and dyadics may have been employed in some problem in the "Simplified Method," and, therefore, the device is properly introduced here, otherwise, like the "Hints on the Differentiation of Vectors," the treatment is hardly thorough enough to be of much service. But since the author also has in view the provision of a general introduction to the use of vector algebra, such sections can be defended. They certainly pique if they do not satisfy curiosity, and, therefore, it is hoped they will tempt the student to venture more deeply into an informing and seductive enquiry.

Marine Oil Engines—Their Construction, Management and Maintenance. By W. D. MARTIN, M.I.E.S. Glasgow: James Munro and Co., Limited. [Price 7s. 6d. net.]

The Running and Maintenance of the Marine Diesel Engine. By JOHN LAMB. London: Charles Griffin and Co., Limited. [Price 8s. 6d. net.]

IT is an interesting commentary on modern engineering developments, that innovations and improvements follow one another successively in such rapid order, that the ordinary method of obtaining knowledge by individual practice and experience of operation is insufficient. Nothing can altogether replace actual practical experience, but that is no reason why such should not be assisted by reference to text-books. The hit-and-miss method is always apt to be expensive and wasteful of time, so that we welcome books such as the two under review, since they serve to give to those who desire to speed up the acquisition of practical knowledge, works of reference to which they may turn in difficulty and from which they may glean much which will assist them in their work. Designers and constructors, furthermore, can never neglect the results of practical experience, since on such a foundation is good design most surely built.

In regard to Mr. Martin's book on "Marine Oil Engines," the scope is very wide covering every type of internal combustion engine which has been applied to marine propulsion, including even the gas engine. Naturally, such description as is comprised within 223 small pages fairly well illustrated by 91 relatively large illustrations, cannot but do other than touch upon most of the points. It would have been much more valuable had certain of the sections been expanded to be more comprehensive rather than attempting to cover such an extremely wide field. The book will serve the purpose of giving to the uninitiated, some idea of the various types and their leading characteristics. This is the second edition of the book, and a chapter headed "War Developments in Oil Engines" has been added. This is most misleading, since this chapter only deals with the type of engine constructed by one maker in this country which was not the standard type adopted by the British Navy. Chapters also are added devoted to extracts from the Board of Trade Regulations regarding motor Certificates and Lloyd's Rules for the construction and survey of Diesel engines and their auxiliaries. One hundred and eleven questions, together with a number of answers, are included towards the end of the book, to assist candidates for the Board of Trade examinations, and in this connection we must condemn a number of the answers to the questions as being so loosely framed as to be distinctly misleading. Take, for instance, the question as to how the explosion is obtained in an oil engine, the answer being "usually an electric spark." A further statement in one of the answers is, that the gas cannot be used expansively in an oil engine as in a steam engine. The answers are not free from misprints.

We value much more highly "The Running and Maintenance of the Marine Diesel Engine," by John Lamb, which confines itself exclusively to the one type of prime mover with the exception of a brief reference to the semi-Diesel engine, which is sometimes fitted to drive auxiliaries of Diesel-engined ships, as, for instance, in the case of the auxiliary machinery in the Rolandseck, a full description of which is given in Chapter 22. In illustrations and in method, the author makes generous acknowledgment in his preface to Supino's "Land and Marine Diesel Engines" by the same publishers. Mr. Lamb's little book is authoritative so far as it goes, in that in many matters the opinions expressed are those derived from actual sea-going experience of the gear and mechanism under description; although very much better indicator diagrams could have been obtained to indicate the various difficulties, such as low injection air pressure, early and late injection of fuel, &c., than those given in Fig. 75 to Fig. 82. The most valuable chapters are the following:—Chapter 11, "Piston Cooling Mechanism"; Chapter 23, "The Maintenance of Diesel Engines"; Chapter 24, "Running Troubles, their Cause and Remedy"; Chapter 25, "Engine Store List." This little volume has been got-up in quite attractive style, the type is good, and the illustrations adequate to the text.

BOOKS RECEIVED.

Proceedings of the Institution of Mechanical Engineers, October to December, 1919. London: Published by the Institution.

Directory of Paper Makers of the United Kingdom for 1920. Forty-fourth annual publication. London: Marchant, Singer and Co. [Price 2s. net.]

Imperial Institute. Monographs of Mineral Resources. Tungsten Ores. By R. H. RASTALL, M.A., F.G.S., and W. H. WILCOCKSON, M.A., F.G.S. London: John Murray. [Price 3s. 6d. net.]

Om Betalning. By W. HOK. Upsalla: Almqvist and Wiksells Boktryckeri, A.-B. [Price kr. 40.]

State of Tennessee Geological Survey. Bulletin No. 22. *Geology and Natural Resources of Rutherford County, Tennessee.* By J. J. GALLOWAY. Nashville: Williams Printing Company.

Committee of the Institution of Civil Engineers, appointed to Investigate the Deterioration of Structures of Timber, Metal, and Concrete exposed to the Action of Sea Water. First Report of the Committee. Edited by P. M. CROSTHWAITE, B.A.I., M.Inst.C.E., Secretary to the Committee, and GILBERT R. REDGRAVE, Assoc. Inst. C.E. London: Published by the Committee, and to be purchased from H.M. Stationery Office. [Price 30s. net.]

The Case for Capitalism. By HARTLEY WITHERS. London: Eveleigh Nash Company, Limited. [Price 7s. net.]

A Pocket Book of Marine Engineering Rules and Tables. By A. E. SEATON, M.Inst.C.E., M.I.Mech.E., Vice-President, Inst.N.A., &c., and H. M. ROUNTHAITE, M.I.Mech.E., M.Inst.N.A. Fourteenth edition, revised and enlarged. London: Charles Griffin and Co., Limited.

The Shipping Year Book: A Desk Manual in Trade, Commerce and Navigation, 1920. Edited by the Editor of *The Shipping World*. London: *The Shipping World* Office. [Price 15s., post free.]

The Coolidge Tube, its Scientific Applications, Medical and Industrial. By H. PILON. Authorised translation. London: Ballière, Tindall and Cox. [Price 7s. 6d. net.]

Metals in Aircraft Construction. By WILFRED HANBY. London: Standard Air Press, Limited, 3 and 4, Lincoln's Inn Fields. [Price 6s. net.]

United States Bureau of Labour Statistics. Bulletins No. 252. *Wages and Hours of Labour in the Slaughtering and Meat Packing Industry*, 1917. [Price 75 cents.] No. 261. *Wages and Hours of Labour in Woollen and Worsted Goods Manufacturing*, 1918. Washington: Government Printing Office.

THE INSTITUTION OF GAS ENGINEERS.

THE Institution of Gas Engineers opened its fifty-seventh annual general meeting on Tuesday morning, June 1, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, under the presidency of Sir Dugald Clerk, K.B.E., F.R.S. There was a very numerous attendance of members from all parts of the United Kingdom, the lecture hall being crowded. The proceedings throughout were interesting.

The usual preliminary business having been disposed of, cablegrams were read from La Societie Technique de l'Industrie du Gaz en France, and from the American Gas Association, sent by the respective presidents, Monsieur H. Laurain and Mr. George B. Cortelyou, conveying hearty greetings and best wishes for a successful meeting. Cordial messages in reply were ordered to be transmitted.

Sir Dugald Clerk then commenced the delivery of his presidential address, in which he dealt with the various important subjects which are now engaging the earnest attention of the Institution. He took for its title "The Future of the Gas Industry," and in his opening remarks pointed out that some of our statesmen appeared to have formed very erroneous ideas of the future of the gas industry. They thought of it as a fully developed entity useful in its time, no doubt, but now exhausted by its existence of over one hundred years, and therefore, incapable of further progress. They considered its capacity for advance inferior or even negligible, compared to its younger rival—electricity. They also failed to understand the magnitude and efficiency of its service to the public, from both the fuel conservation, and financial standpoints.

In actual fact, at the present moment, the gas industry was highly efficient in the production of light by the incandescent mantle. In the generation and distribution of motive power it was thermally considerably more efficient than electricity, and in the general production of heat for domestic and manufacturing purposes it was overwhelmingly more efficient than electricity.

As to the future, developments were impending in the gas industry, by no means less important than those in view in the case of electricity. Great developments were coming in both industries, provided that legislative interference was reduced to a minimum, and gas and electricity were allowed to compete freely in the service of light, power and heat. Thermal and financial factors would then soon determine the selection and division of the three types of service in the most advantageous manner to the country. Under such circumstances gas and electricity would share in distributing light and power, probably in nearly equal dimensions; but for the public supply of heat, gas would take in the future, as it did now, much the greater proportion.

Gas, like electricity, had been greatly hampered in the past by unwise restrictive legislation, and it was to be hoped that improving changes in the law would leave both industries free to develop so as to render the maximum service to the country.

The gas engineers of the United Kingdom were proud of the past history of their industry, and they were enthusiastic workers for and believers in its greatly increased expansion, by improved service to the public. The trend of improvement in the generation and use of town's gas had taken two directions within the industry, both capable of high thermal and financial efficiency.

The first method was that of destructive distillation of the coal treated and the generation of gas by the process, leaving coke in the retort and collecting tar and chemical products eliminated from the gas, before distribution for use. The second method consisted in converting a portion of the coke produced into water gas and adding that gas to the distilled or "straight" gas. This method increased the proportion of total heat of the original coal transferred to the gasholder. The second method had various modifications such as adding producer gas by the steaming in vertical retorts, as well as by generating carburetted or plain water gas in separate producers. It also included processes for the complete conversion of the whole coal into gas, processes which were now in the early manufacturing stage.

According to the older method, carbonisation had been closely studied with a view to the reduction to a minimum of heat used and lost in the process, so that the whole of the volatile hydrocarbons might be driven off in the retorts, be they horizontal, inclined, or vertical; and coke and tar with the gas so produced formed the products, gaseous, liquid and solid, from which heat power and light might be obtained at a minimum of fuel consumption and money expenditure.

By this method the original heat of the coal was divided in the proportions given on the next page.

Assuming the whole of the heat loss to be debited against the gas, then the thermal efficiency of gas production was, in this case, 62·5 per cent. This might

be taken as the highest thermal efficiency which could be obtained by a gas-making process which consisted essentially of destructive distillation. The average efficiency of gas production throughout the country was much lower at present; it was about 46 per cent.

	British Thermal Units.
Coal gas produced	25
Coke	54
Tar	6
	85
Heat used and lost	15
Total original heat of coal	100

If the double process were capable of performance in one plant at the same heat loss, namely, 15 per cent., then the thermal efficiency of gas production was 77 per cent. and the distribution of heat in the products was:—

	British Thermal Units.
Mixed coal gas and water gas	50
Coke	30
Tar	5
	85
Heat used and lost	15
Total original heat of coal	100

Obviously, if the whole of the coal were converted into mixed gas with the same heat loss and use, then the thermal efficiency of production rose to 85 per cent. To Sir Dugald's knowledge such an efficiency had never been obtained in any water-gas plant yet built. The necessity of using an alternating process of blowing up and steaming for gas generation made it improbable that the heat loss could be sufficiently reduced.

For some years past attempts had been made in this country and on the Continent to work out a commercially effective form of gas plant intended for the complete gasification of coal, and some progress had been made in Holland. In our own country progress had also been made. An experimental apparatus had been erected at the works of the Grantham Gas Company, and preliminary results of some months' working had been published by Mr. R. G. Shadbolt, the engineer of the company, from which it appeared probable that a thermal efficiency of complete gasification of 70 per cent. might be expected when the regular gas manufacturing stage was reached. Similar apparatus was being installed at Normanton under Mr. Hudson.

After referring to considerations in connection with the early stages of gas-engine development, in which gas producers, both pressure and suction, were employed, the president pointed out that the principal advocate of complete gasification on the gas producer principle, with the accompanying large proportion of inert gases, was the well-known and energetic gas engineer, Mr. George Helps, of Nuneaton, whose proposals he had carefully studied. He had also read through the various patent specifications in which Mr. Helps described his inventions, and had to confess he found it difficult to discover in any precise way in what manner Mr. Helps intended to reduce fuel consumption and increase thermal efficiency. It was plain, however, that he attached special value to the presence of large quantities of inert gases in the gas which he would supply. It was true that the high thermal efficiency of the suction and other gas producers depended on the fact of internal heating due to the partial combustion of carbon within a generator, and the decomposition of steam accompanying the air by the incandescent carbon. For this method it was necessary to allow a large proportion of inerts in order to obtain a complete gasification and a high thermal efficiency. Mr. Helps appeared to consider, however, that many of the advantages of a high efficiency gas could be obtained by adding atmospheric air to ordinary coal gas distilled from coal in a retort in the usual way, and, moreover, he drew conclusions as to low thermal value gas from mixtures of such gas and air. He considered atmospheric air to be an inert body and reasoned accordingly, but the procedure was quite erroneous. Sir Dugald Clerk appreciated Mr. Helps' enthusiasm and good intentions, but he was quite wrong, and did not assist the gas industry by such reasoning. Atmospheric air was not an inert body, but was a necessity of combustion; without it gas could not burn and without it no heat could be evolved by the use of gas.

The Gas Investigation Committee of the Institution had exhaustively determined the effect of inerts, and, broadly, the addition of nitrogen up to 30 per cent. interfered but little with the value of a gas for producing heat and light, but the addition of carbonic acid became rapidly prejudicial after about 10 per cent. With regard to power, weak producer gas of 130 British thermal units, and blast furnace gas of 100 British Thermal units per cubic foot gave high efficiencies in gas engines with greater ease than did rich gases of 500 British thermal units and over, such as coal gas, coke oven gas and natural gas.

The president then proceeded to discuss questions bearing on the three broad methods of gas generation, and asked: "What, then, should be the ideal of the gas industry of the United Kingdom"? He said it was plain that for all purposes, especially for motive power and heating, it was necessary that the heat unit should be supplied to the public at the lowest price possible consistent with financial stability and a reasonable return on the necessary capital. In 1917 the gas industry carbonised about 20,000,000 tons of coal. The heat of 10·8 million tons was used to produce and distribute the coal gas utilised in the United Kingdom, while the heat of 9·2 million tons remained available for use in the form of solid coke and semi-liquid tar and oil. At 45 per cent. thermal efficiency of gas production the gas generated contained 25 per cent. of the original heat of the coal, or that given out by completely burning 5,000,000 tons. If it were possible to generate gas at an efficiency of 80 per cent. from the whole coal without production of coke, then the heat of 16,000,000 tons of the 20,000,000 tons would be available for distribution. Thus, dealing with the same total coal as at present carbonised, the gas industry would have a supply for distribution of more than three times the present potential heat, light, and power requirements of the country. In his opinion the country could absorb this greatly increased supply.

As indicating the comparative cost of 100,000 British thermal units in various forms, the following table from the recently published report of Sir George Beilby, Director of Fuel Research, was quoted:—

	d.
In good coal at 27s. per ton, 100,000 British thermal units cost	1
In good coal, at 54s. per ton, 100,000 British thermal units cost	2
In gas of 500 British thermal units per cubic foot, at 4s. 2d. per 1,000 cub. ft., 100,000 British thermal units cost ...	10
In kerosene, at 2s. 6d. per gallon, 100,000 British thermal units cost	19
In petrol, at 3s. per gallon, 100,000 British thermal units cost	25
In electricity delivered for heating purposes, at 2d. per Board of Trade unit, 100,000 British thermal units cost ...	58

The efficiencies and cost of gas from Mond bituminous producers in ordinary use were considered, and the president passed on to the new Bill recently introduced into Parliament, which would carry into legal effect the recommendations of the Fuel Research Board. It afforded a large measure of liberty enabling the gas industry to settle for itself, by the introduction of improved methods of gas production, the exact nature of the modified processes to be employed to supply the public with the best gas suited to produce heat, power, and light at the lowest practicable price, and with the maximum economy of coal.

He advocated the formation of an establishment devoted solely to the studying, testing, and reporting on the construction and operation of all forms of gas-consuming apparatus. Certificates should be granted to manufacturers and inventors, giving the results of the various tests. He was convinced that its effect would be to stimulate invention and discovery in gas appliances. H.M. Fuel Research Station at Greenwich, under Sir George Beilby, would be of great assistance to the gas industry in supplying accurate and impartial tests of all gas production processes, but a "Gas Institute" was also required for the production and valuation of gas-consuming apparatus and the granting of certificates of performances.

In conclusion he expressed the opinion that the gas industry would progress by improvements on the distillation method designed to reduce to the lowest possible point the heat required for carbonising, and adapted to receive a larger proportion of the heat leaving the retort setting. Complete gasification might be desirable under some circumstances, but it would depend on the commercial factors of the sale prices of coke and residuals. As to the two great industries of gas and electricity, friendly relations should be cultivated between them. There was ample room and need for both.

A vote of thanks to the president for his address was heartily accorded, on the proposal of Mr. S. Glover, of St. Helens, seconded by Mr. George Hislop, of Paisley.

The annual report of the council and accounts for the year 1919 were then presented, indicating useful work accomplished, increasing membership, and a satisfactory financial status.

(To be continued.)

DIESEL MARINE ENGINES.—Owing to the increasing demand for Diesel marine engines, "Lloyd's Register of Shipping" have, at the request of Messrs. Sulzer Brothers, appointed Mr. W. G. Vallis as ship and engineer surveyor for Switzerland, with residence in the district of Winterthur.

INDUSTRIAL NOTES.

AT the Aberdeen Congress last week of the National Union of General Workers, Mr. J. R. Clynes, M.P., was elected president, and Mr. Will. Thorne, secretary, both by a very large majority.

Speaking at the fourth annual conference of the National Democratic and Labour Party, British Workers' League, held at Sheffield last week, Mr. J. A. Seddon, M.P., chairman of the General Council, dealing with the relationship between Labour and Capital, said that as far as he was able to apprehend the current thoughts and needs of the day, he saw no other agency that could so well realise cordial relationship between the two as the Whitley Councils. He would like to see these Councils invested with mandatory powers by majority rule, and it was high time that Government undertook the full examination of the work of the Councils. To restrict output, he added, was an offence against the whole community; there could be no excuse for not fulfilling one's duty. A resolution was passed at the conference agreeing with the principle of nationalisation of certain industries, but declaring the present time inopportune and expressing the view that some system of industrial co-operation on the main lines of the Whitley Council scheme was more practicable and desirable at this juncture.

The London correspondent of *The Glasgow Herald* states that the shipbuilding and engineering trade unions intend to send up for consideration in June applications for very large increases of wages. On the Clyde and elsewhere in the north-west district a demand has already been formulated for an increase of not less than 1s. an hour; and at the recent annual meeting at Plymouth of the federated trades there was a serious talk of recommending the affiliated societies and others to follow the example generally. Nothing was, however, done, the meeting merely deciding to call a conference of all the unions involved further to discuss the matter. Whether the units of the new Amalgamated Engineering Union which are not in the federated trades will agree to attend such a conference remains to be seen. But the correspondent gathered from conversations which he had with men from various provincial centres that 1s. an hour was considered by them to be too much. Sixpence an hour, or 23s. 6d. per week, will be, in all probability, he was given to understand, the national demand of both shipyard and engineering trades.

Members of the Federation of Master Printers and Allied Trades, the Provincial Newspaper Proprietors' Organisation, the Executives of the Printing and Kindred Trades Federation of the United Kingdom, and representatives of the Bookbinders' Union met last week at a private conference in the Stationers' Hall, London. At the close of the meeting, the following statement was made to the Press Association: "The conference considered applications for increases in wages put forward by members of the unions mentioned. The claims ranged from 12s. 6d. for women, to 30s. for men. Certain terms of agreement were provisionally fixed upon. These will be submitted to the Councils of the organisations concerned. If the terms are accepted, considerably improved working conditions will come into effect at an early date."

Last week the Wages Board resumed its sittings when evidence for the railway companies in regard to the effect of the increase in railwaymen's wages was given. It was submitted on behalf of the companies that the railways were not in a position to bear the extra burden without the imposition of further charges, and that the public had become concerned at the prospect of dearer fares all round and more expensive travelling generally. Mr. A. Hobson, president of the Associated Chambers of Commerce, said that increases in railway rates in the past had had the effect of driving away from Sheffield many important industries. He expressed the opinion that any further increase in these rates would have the effect of precipitating a considerable collapse in many of the important industries of the country, and would also have the effect of largely transferring the carriage of merchandise from the railways to the roads. Another effect would be the diversion of trade, in which connection he much more feared the competition of America than that of Germany, although Germany was bound to become a serious competitor of ours. He did not object to a man receiving high wages so long as he earned them; that was the whole crux of the matter, high wages must be attended with efficiency, otherwise wages were bound to fall. A letter was read from Mr. Stockton, president of the Manchester Chamber of Commerce, saying that any increase in existing railway wages would prove disastrous to the industries of the country, and especially so to those of Manchester.

The problems facing the makers of paper throughout

the whole world are probably greater to-day than they have ever previously been, says *The Paper-Maker*. It is common knowledge that owing to a world-wide shortage of raw materials, together with difficulties as to freight and a position not without difficulty as to labour, the world is not producing within 30 per cent. the quantity of paper absolutely necessary for our everyday requirements. Wood pulp is in Great Britain dearer to-day than it was during the war, even when the submarine menace was at its worst. Matters are becoming daily more difficult, and it is not impossible that the acute shortage of paper, particularly in Europe, will make it incumbent upon the community to economise greatly in the amount of paper consumed. Something like alarm exists in the newspaper circles in consequence of soaring prices.

The Sheffield and Rotherham members of the National Amalgamated Union of Enginemen and Firemen came out on strike last Saturday against the three-shift system. From an official statement on the matter made by the Sheffield and District Engineering Trades Employers' Association we take the following: Negotiations took place in the commencement of 1919 in regard to the introduction of the three 8-hour shift system for the set or process men in rolling mills, forges and press shops, and it was realised that arrangements would also have to be made for the subsidiary classes of men attached to these departments, *i.e.*, boiler firemen, locomotive drivers, crane men and about 20 other classes, who would also be transferred from the 47-hour working week to the shift system. In dealing with these classes of men, the Employers' Association was faced with the serious difficulty that they belonged to at least six distinct unions, namely, the Iron and Steel Trades Confederation, the National Amalgamated Union of Enginemen, the Winding and General Engineers' Society, the National Union of General Workers, the National Amalgamated Union of Labour, the Workers' Union. The Employers' Association has continued negotiations week by week for nearly a year; finally, it came to the decision that so complicated was the matter that it could only be settled by appeal to the Industrial Court of Arbitration. Three unions, the Winding and General Engineers' Society, the National Union of General Workers and the National Amalgamated Union of Labour, agreed to the terms of reference. The National Amalgamated Union of Enginemen and Firemen refused to submit the matter to arbitration. The Arbitration Court sat at the Town Hall, Sheffield, on January 8 last, and after an exhaustive hearing of the arguments on both sides issued their award known as No. 84. This states that the shift system is to apply to those steam service men who serve rolling mills, forges and press shops, i.e. the system to which the set men in these departments are now working. In order to provide some compensation for the difference in overtime rates, the Court increased the base rates per shift. Moreover, under the shift system the consolidated war bonus now amounts to 8s. 8d. per shift, which is a considerable advantage to the men under the shift system as compared with those on the 47-hour system. As a result of further negotiations, two other unions, the Iron and Steel Trades Confederation and the Workers' Union intimated that they were prepared to accept the award. Five out of the six unions having agreed, the employers decided that they could not postpone action on account of the opposition of one, the National Amalgamated Union of Enginemen and Firemen. The employers say that the cost to them in cash of introducing the award and the third shift of men is a very considerable one as, compared with two men employed at present, three men would be employed in the future, so that the employers have nothing to gain from the financial standpoint. The three-shift system would have the effect of providing employment for a large number of extra men. It has been stated that one of the objects of the employers in putting into force this arbitration award setting up the shift system, was to deprive the men concerned of the advantages which they anticipate from an agreement which was arrived at between the Engineering and National Employers' Federations and the National Union of General Workers, at a conference held recently at York. This statement, however, is incorrect. This particular agreement only applies to men in engineering, foundry and boiler shops, and does not apply to the classes of men covered by this award, who are in rolling mills, forges and press shops. The effect of the strike on the part of these enginemen and firemen, to the number of about 2,000, has been to throw out of work over 20,000 other men, and has led to the closing of several of the larger steel works in Sheffield and district.

The eighty-second quarterly balance sheet to March 31, 1920, recently issued by the General Federation of Trade Unions, showed the societies forming part of the federation to number 183, with a total membership of 1,480,108, the funds in hand being 120,393*l*. The report states that the quarter ending March 31 differed materially and happily from the one immediately preceding it. Then it was necessary to deplore the payment of 154,542*l*. in federation benefit, while the contributions totalled 42,760*l*. In the last quarter, the expenditure on benefits had been 15,744*l*., and the contributions 22,663*l*. The main item of expenditure in the March quarter had been the sum of 13,160*l*. paid to the Friendly Society of Ironfounders and was additional to the 49,359*l*. already paid in connection with their national dispute.

The fourteenth annual report, for 1919, of the Skilled Employment and Apprenticeship Association, 53, Denison House, Vauxhall Bridge-road, S.W. 1, states that seven committees had been actively engaged in the work during the whole year, and these committees received an appreciably larger number of applications than the previous year (1,303 compared with 1,158). Forty per cent. of the boys were successfully placed, and 47 per cent. of the girls, the same proportion as in 1918; one-quarter of the boys and one-sixth of the girls were apprenticed, a better proportion, especially in the case of the girls. Among the boys' trades, the engineering and heavy metal trades remained the most popular, absorbing two-fifths as in the previous year. The numbers in the instrument-making trades, which was next in importance, had fallen off, while the jewellery and light metal trades showed a noticeable increase. In the girls' trades the needlework trades and the clerical and stock-room work had reversed their positions this year, and the former had absorbed half the girls. The numbers entering the other trades had not altered materially.

An interesting pamphlet, reprinted from *The Times*, on "The Problem of Dock Labour," by A. Shadwell, M.A., LL.D., can be obtained at the price of 1*s*. from Messrs. Longmans, Green and Co., 39, Paternoster-row, E.C. It reviews the situation in detail. Dealing with the recent advance in the dockers' wages, it says: ". . . Mr. Bevin argued that this could be given without passing on the cost, but he was undoubtedly under a misapprehension about the dock employers. He thought the money could be got out of the shipowners, and cited their gains in support of his argument. If he can get anything out of the shipowners all the rest of us will be very pleased to see the dockers 'share the swag,' if swag there must be; but I do not see how he is going to do it. In any case, it will be only a fraction of the whole, since the shipowners employ no more than one-fourth of the dock labour, a fact which he apparently did not know. The large port authorities must pass on the cost; they are public statutory bodies, which make no profits and have no surplus to pay additional charges for labour. . . . Very heavy additional charges will be placed on sea-borne commodities to pay the dockers' new wage. Nor is that all. It is said, and apparently on good grounds, that the coastal traffic cannot pay the increased cost. Its revival, already made difficult by existing charges, will be completely prevented, and the public will lose this means of relieving railway congestion and lowering the cost of inland transport . . ."

COLD STORAGE BARGES FOR THE RHINE.

By demand of the allies the German Government had, in spring, 1919, to supply some cold-storage lighters for the port of Antwerp, especially to facilitate the transport of frozen meat. The Antwerp cold stores not having railway connection, it is said in the *Zeitschrift des Vereines Deutscher Ingenieure* of May 1 last, that the carcasses were taken by motor from the quays to the stores, about 3 miles off, and thence later to the railway station, another 2 miles. One of the three barges fitted up, the "Köln 13," was illustrated in the issue mentioned. The main dimensions are: Length over all, 79·95 m.; length on water line, 78·08 m.; beam, 9·48 m.; displacement at 2·5 m. draught, 1,350 tons; gross capacity, 1,715 cub. m. The 36-h.p. horizontal Diesel engine, an ammonia refrigerator, and dynamo, all in duplicate, are placed amidship. Cooling coils are carried along both sides of the ship and are placed also fore and aft; the fans and air trunks withdraw the air high up in the holds and deliver it down the cooling coils which are of galvanised iron and provided with radiator fins; wire netting prevents the freezing of the carcasses to the pipes. The carcasses are supported on laths, the air circulating horizontally across the holds. The elaborate heat-insulation of the barge bottom and sides is affected by means of light-weight bricks, obtained by kilning silicious algae, of a special mortar (sterchamol) and of slabs of a peat preparation, known as torfoleum; the bottom is built up of cells in accordance with Knoblauch's experiments as to the advantages of heat insulation by the aid of small spaces of quiescent air. The insulating materials mentioned are the speciality of the Hamburg firm of H. C. Pohlmann; the general contractors were the firm of A. Freundlich, Düsseldorf. Of the total equipment weight, 400 tons, the heat insulation alone makes up 340 tons; the machinery weighs 40 tons and the pipes 16 tons. The barge arrived at Antwerp in July, 1919, and was at once put to use. It was found that not more than 450 tons of frozen meat could be accommodated on board, and that the barge then drew only 1·60 m. of water. This did not facilitate its refrigeration, and as two hatches had simultaneously to be kept open frequently, while loading and unloading, both the engine sets had to be worked during the hot summer, though under ordinary conditions one set was sufficient. On the other hand, the special arrangements adopted for keeping the deck flooded with water proved inconvenient, and were dispensed with; in ocean steamers the cold stores are below the lower decks; of course in the barge they are directly under the deck, which is exposed to the sun. Yet the barge services reduced the cost of the transhipment of the frozen meat very considerably. Descriptions of the other two barges, of somewhat different constructions, were to follow.

NEW STATES AND PATENTS.

It is not generally known among engineers who file applications for their inventions in a number of foreign countries, that several of the new States which have come into existence since the Peace Treaty provide already patent laws of their own or have such in contemplation, and that unless special steps be taken their present patents will not cover them for these territories. In addition, it is necessary that they should have this in mind when taking future patents. The following notes on the boundaries, the industries and products of some of the new States may, therefore, be useful.

As to the central European States from the original Austro-Hungarian Monarchy three States have been created: New Austria, New Hungary and Czecho-Slovakia. Further portions of the former empire of New Austria, namely, Galicia and some regions in Austrian Galicia with parts of Prussia and Russia constitute new Poland. The Jugoslav State, is derived from part of Austria, part of Hungary, Bosnia, Herzegovina and Servia. Esthonia, Lithuania, Ukrania also come into question and in addition Palestine, Mesopotamia and Syria may be involved.

Austria.—The most important industries here are machinery, metal goods, engines for automobiles and aircraft, electrical apparatus, articles of wood, leather and fancy goods and brewing. The most important agricultural and mining products are wood, common salt and iron ore, and large water power is available.

Czecho-Slovakia.—Agriculture and industry are highly developed in the western part. The northern portions have an almost exclusive German population with the well-renowned textile, glass and porcelain industry. In the central part there is a large manufacture in machines, automobiles, arms, sugar and brewing, and the chemical industry is progressing.

Hungary.—This is mostly low-lying country and the occupation of the majority of the people is agriculture. The chief features of industry deal more particularly with brewing, the manufacture of sugar and machinery.

Jugoslavia.—Part of the country is mountainous but the rest is very fertile. There is little development yet in the mines and industry generally. Vast forests are available.

Poland.—This is rich in agricultural products and there are important mining deposits, chiefly iron ores and coal, common salt, petroleum and salts of potash. The most important industries are the textile industry, brewing and the manufacture of sugar. The greater part of the land is lowlying.

Ukrania to the north-east of Roumania, *Lithuania* to the north-east of Poland, and *Esthonia* further north with Reval as its capital, have not yet provided patent laws except that a measure of protection is being considered by the last-mentioned State.

HYDRO-ELECTRIC POWER FOR AUSTRIAN RAILWAYS.—Last month the Austrian Government asked for a grant of 3,560,000,000 kronen for the electric working of the State railways. The present projects provide only for hydro-electric plants of about 22,000 h.p., and the estimate would be very much smaller were it not for the depreciation of the Austrian credit. With the actual prices for imported coal and the passing of the Austrian coalfields into the possession of the newly-created States, the electrification of the railways has really become a vital question. The Vienna metropolitan railway, built in peace time at an expenditure of 133,000,000 kronen, equivalent to at least 5,000,000,000 at the present time, is practically closed owing to the want of fuel, and all that capital is lying idle. Nothing can be done without the aid of foreign capitalists, and the financial situation makes both the borrower and lender hesitate.

COMPOUND LOCOMOBILE WITH SUPERHEATER.

CONSTRUCTED BY MESSRS. MARSHALL, SONS AND CO., LIMITED, ENGINEERS, GAINSBOROUGH.

(For Description, see opposite Page.)

Fig. 1.

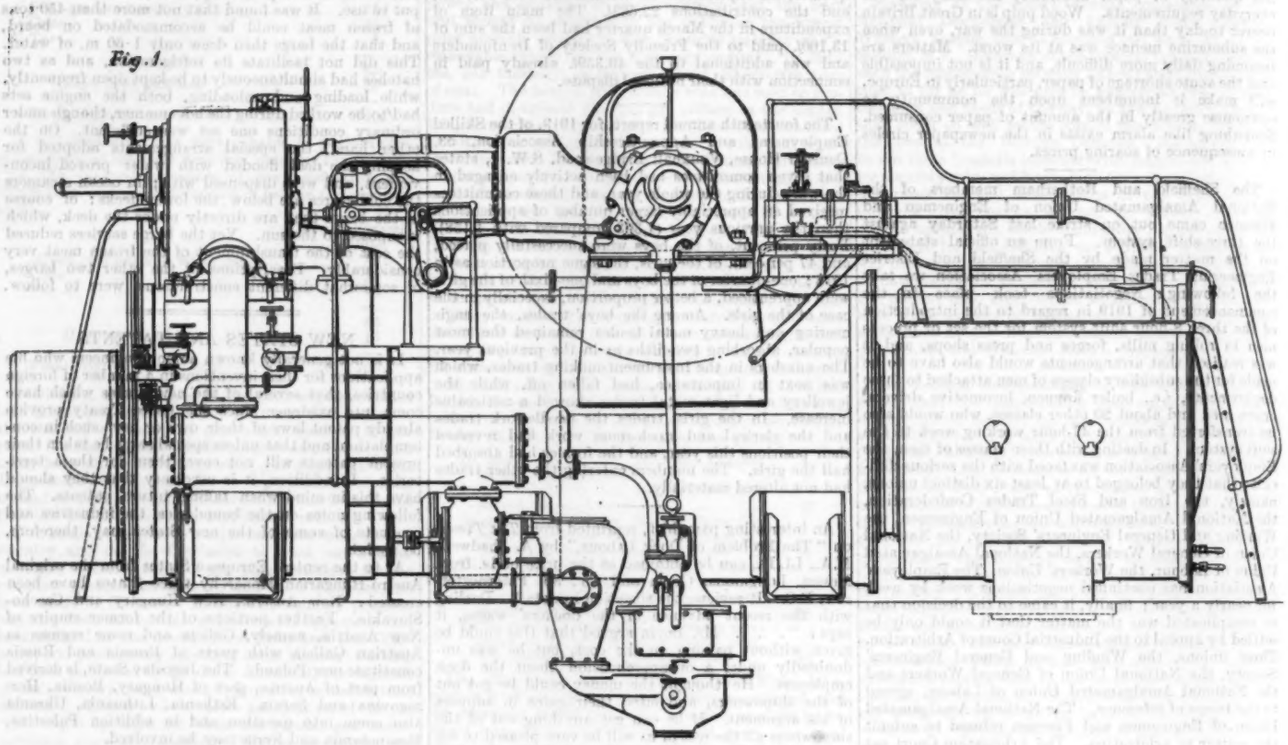
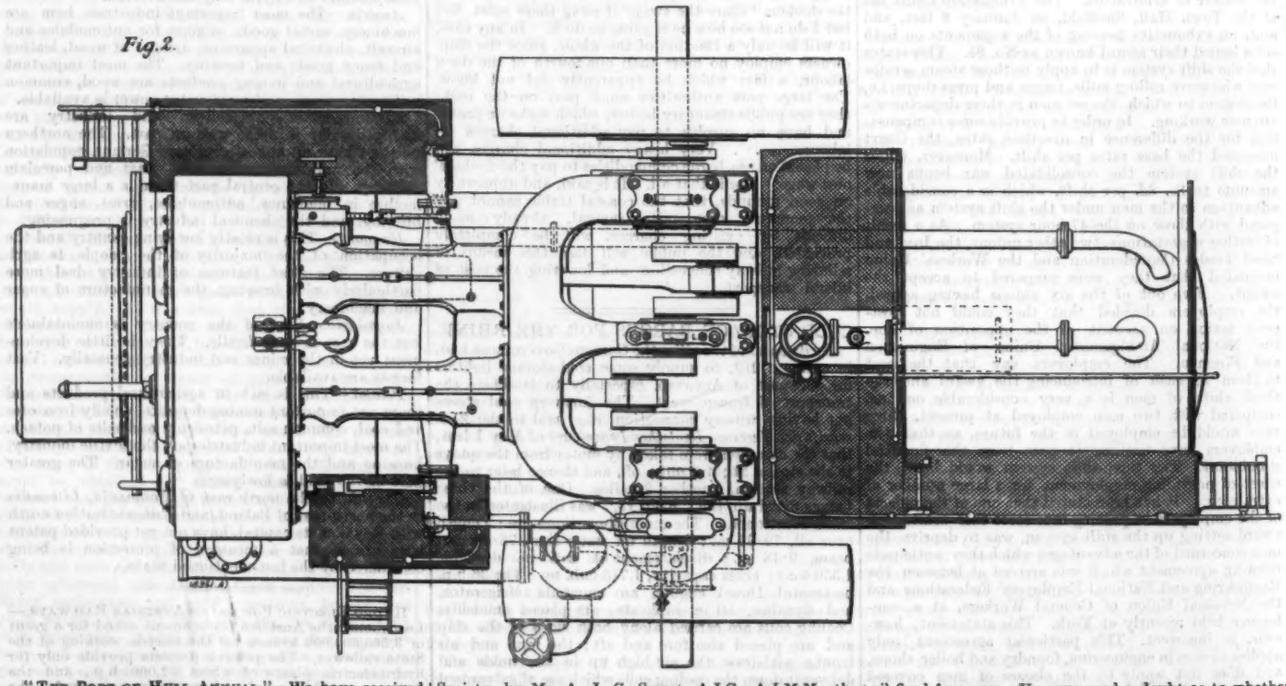


Fig. 2.



"THE PORT OF HULL ANNUAL."—We have received from the editor, Mr. H. E. Cooper Newham, a copy of this annual for the current year. It is published at the office of *Hull Trade and Transit*, 13, Bishop-lane, Hull, and gives illustrated information on the commerce and industries of the port and town, and numerous statistics. It contains a chapter in French and one in Spanish, both dealing with the activities of the port, the facilities it offers, and with the various industries in its immediate vicinity.

BRASS MELTING.—In a lecture on this subject delivered on the 20th inst., to the Birmingham Metallurgical Society, by Mr. A. J. G. Smart, A.I.C., A.I.M.M., the important question of fuel economy and its relation to the increased efficiency of brass-melting furnaces was dealt with. Mr. Smart expressed the belief that more rapid progress would be made following upon a healthy competition between the various fuels that could be used. Notwithstanding the obvious disadvantages of coke-fired furnaces for brass melting, these furnaces, he said, were still the most generally resorted to, and there were sound theoretical reasons why this should be the case. Their efficiency during the past few years had been much improved. It was unfair to compare the most obsolete coke furnace with the most modern gas or oil-fired furnaces. He expressed a doubt as to whether it was advisable to convert our coal into town gas and subsequently to burn this gas in the ordinary gas-fired furnace. Firing by means of pulverised coal or producer gas, on either a regenerative or recuperative system, was a more efficient method of utilising our coal. It was doubtful whether there was at the present time a readily available source of liquid fuel suitable for metal melting, sold at a price to compete with coke in thermal efficiency. Owing to the price required, per unit, there seemed to be little prospect for the use of electricity—otherwise an ideal means of metal melting—becoming a practical proposition in this country for brass melting.

COMPOUND LOCOMOBILE WITH SUPERHEATER.

CONSTRUCTED BY MESSRS. MARSHALL, SONS AND CO., LIMITED, ENGINEERS, GAINSBOROUGH.

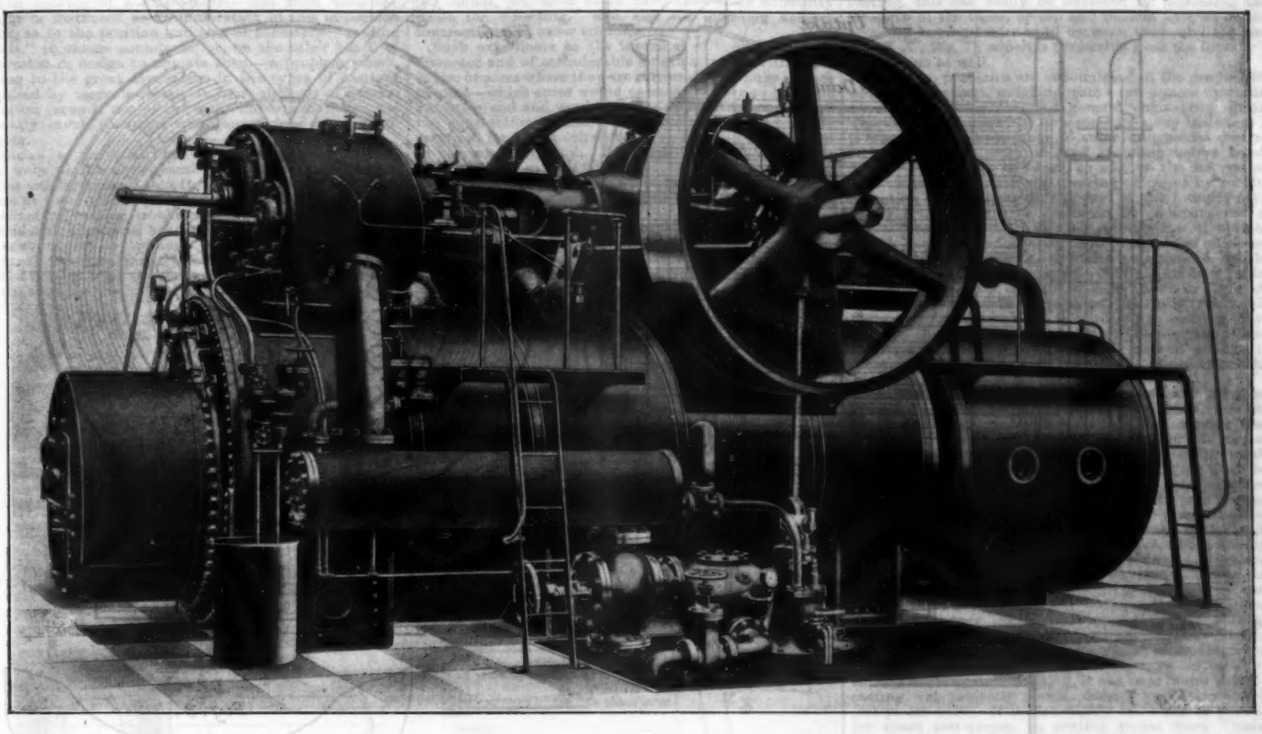


FIG. 3.

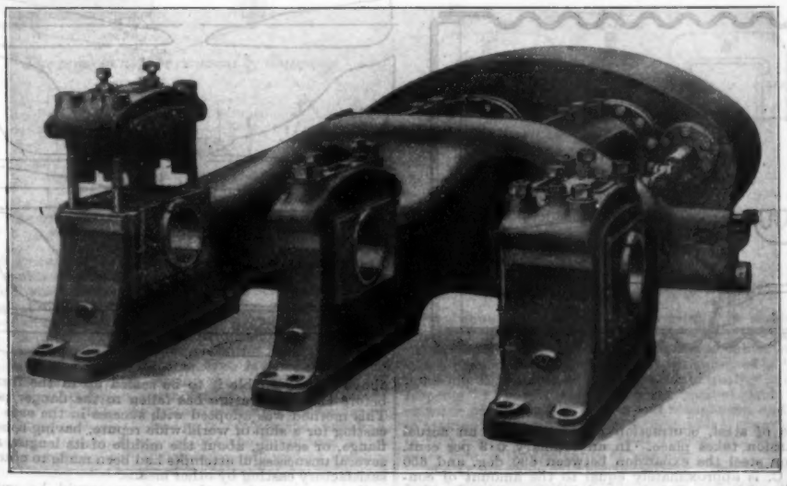


FIG. 4.

IN our description of the works of Messrs. Marshall, Sons and Co., Limited, at Gainsborough, we stated that the firm were building locomobiles of various sizes. We now illustrate, in Figs. 1 to 8, on pages 766 to 768, one of the larger sizes of this type of engine built by the firm in question. This engine is a two-cylinder compound mounted on a cylindrical tubular boiler. Drawings showing outside elevation and plan are given in Figs. 1 and 2, from which the general arrangement will be gathered, while the reproduction of a photograph in Fig. 3, above, also gives a good idea of the installation.

The cylinders are 13 in. and 25 in. in diameter by 22 in. stroke. The cylinders and steam chests are all in one casting. The valves are of the balanced piston type, that for the high-pressure cylinder having a diameter of 5¼ in. and a travel of 6 in., while the low-pressure cylinder valve is 11½ in. in diameter and has a travel of 8¾ in. Both the cylinders and the steam chests are bushed. The stuffing boxes are fitted with metallic packing. The crossheads are designed with adjustable slippers and work in bored guides. The main frame unit composed of cylinders, guides and main bearing casting, is shown in the view, Fig. 4. These are all supported on pressed steel brackets riveted to the boiler. The engine is regulated by a centrifugal crank governor controlling the eccentric of the valve for the high-pressure cylinder. The piston valve for the low-pressure cylinder is driven off an eccentric which also operates the air pump. Both valves are driven through rockers working on brackets forming part of the main frame unit.

The boiler is 6 ft. 1 in. in diameter and has a length of 16 ft. It is fitted with a single flue 4 ft. 3½ in. in external diameter and 7 ft. 7 in. long. The tubes are 129 in number and 2¼ in. in external diameter. They are 8 ft. 2 in. long between tube plates. The total heating surface is 769 sq. ft., made up of 690 sq. ft. of tube surface, and 79 sq. ft. of flue surface. A smoke-box superheater, of which drawings are given in Figs. 5 and 6, page 768, provides 600 sq. ft., while a horizontal feed heater, through which the exhaust from the low-pressure cylinder passes on its way to the condenser, furnishes 65 sq. ft. of heating surface. The engine is furnished with a jet condenser and Edwards' type vertical air pump. The feed pump is fixed to the air pump casting and works off the same eccentric rod. The feed is passed through the tubes of the feed heater. An injector is fitted to the boiler as a standby.

	Condensing.	Non-Condensing.
Duration of test	4 hr. 50 min.	2 hr. 17 min.
Temperature of feed ...	121 deg. F.	186 deg. F.
Steam pressure, pounds per square inch	180	180
Superheat, deg. F.	155·6	172
Vacuum	27 in.	—
Revolutions per minute ...	165	165
Brake horse-power	307	241
Coal consumption per brake horse-power per hour ...	1·39 lb.	1·7 lb.
Calorific value of coal, British thermal units	11,500	11,500
Mechanical efficiency, per cent.	95·7	94·5

The boiler pressure is 180 lb. per square inch. The grate, Fig. 7, is a short extension pattern for wood or inferior coal, and has an area of 21 sq. ft. Other types of grate can be arranged to suit the class of fuel available. The whole flue and tubes unit can be taken out of the boiler. This, as may be imagined, is a great convenience for cleaning. Sometimes a spare unit is supplied, when the time taken in getting the engine again under steam is considerably reduced, as this can be inserted and the one taken out scaled subsequently. The gases pass round the smoke-box and out by a downtake below. The drawings, Figs. 5 and 6, show the usual type of superheater with coils connected to a header, but this drawing does not show the actual arrangement adopted for this size of engine.

The cylinders and piston valves are supplied with a mechanical oil pump; the crankshaft bearings have ring oilers, and the other parts sight-feed

DETAILS OF COMPOUND LOCOMOBILE WITH SUPERHEATER.

CONSTRUCTED BY MESSRS. MARSHALL, SONS AND CO., LIMITED, ENGINEERS, GAINSBOROUGH.

Fig. 5.

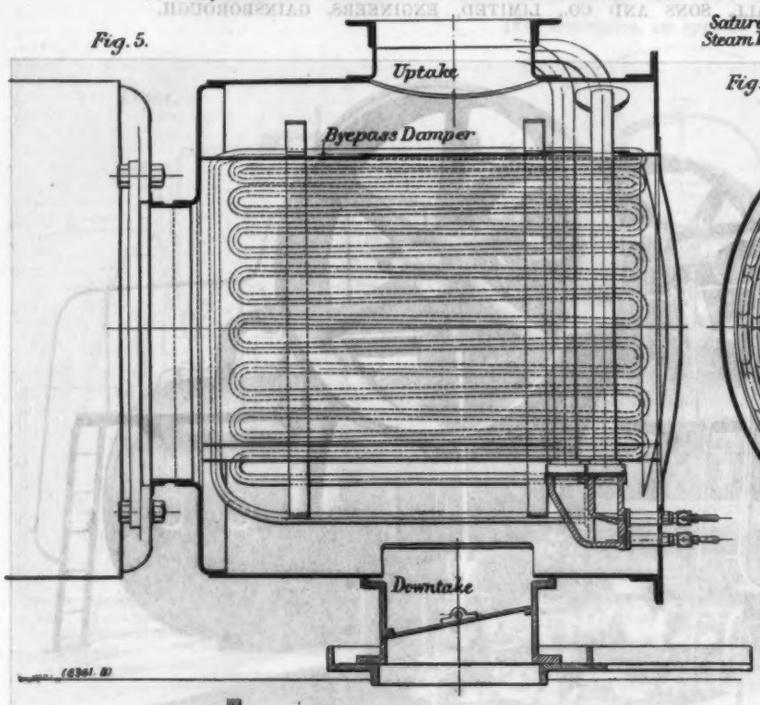


Fig. 6.

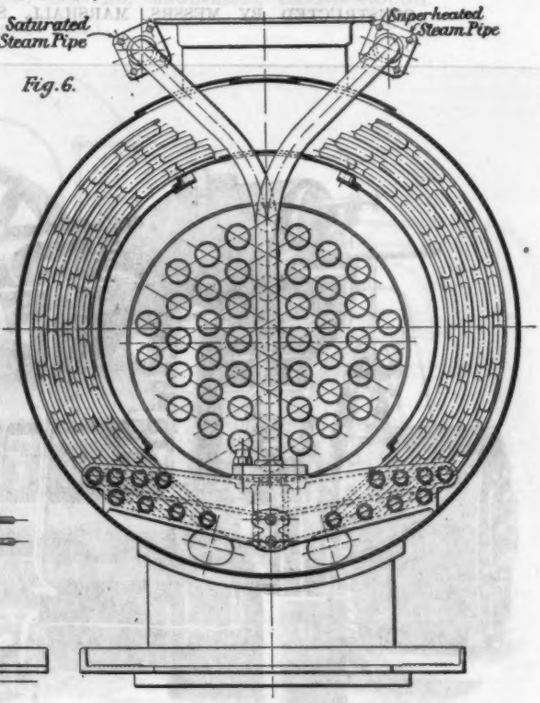
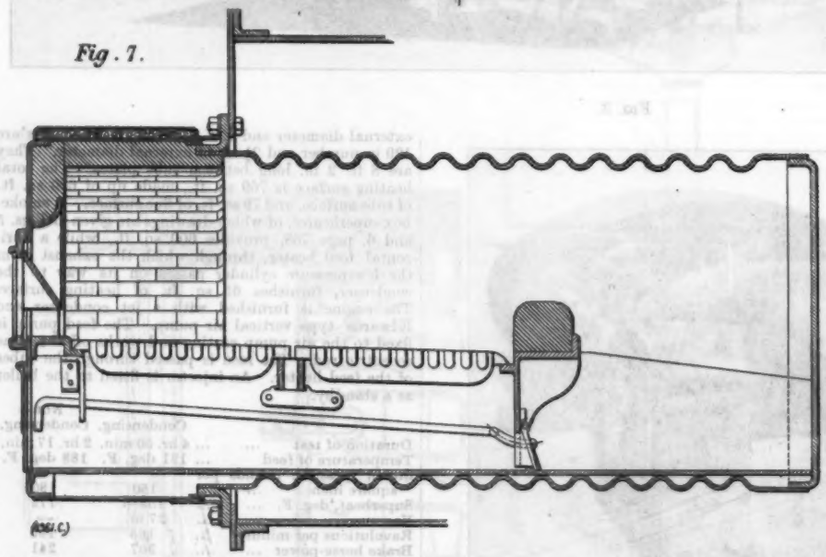
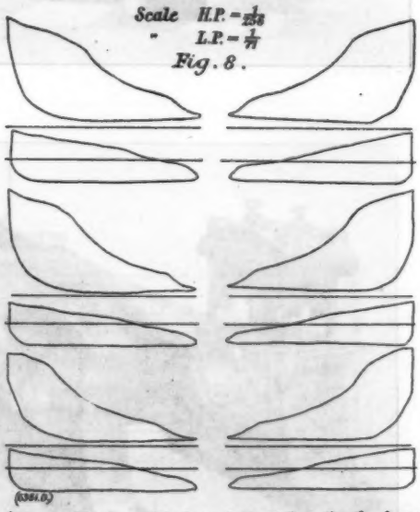


Fig. 7.



Scale H.P. = 1/25
" L.P. = 1/17

Fig. 8.



lubricators. We give in Fig. 8 above some typical indicator cards taken from this engine, and on the previous page are given some tabulated results of trials made on the installation at the makers' works.

PRACTICAL NOTES ON THE DESIGN AND TREATMENT OF STEEL CASTINGS.*

By GEORGE F. PRESTON, Sheffield.

It is much to be regretted that, between engineers and steel founders, there is so little interchange of the knowledge gained by experience on the subject of the production and treatment of steel castings, a subject of very considerable importance to a large proportion of the trades carried on in this country, as greater reliability in steel castings would result from a better understanding of requirements and difficulties by users and suppliers.

Steel castings are used extensively for very diverse purposes. Some difficulties which have arisen in the foundry have been due to the non-appreciation of the fact that, at the recalescence point Ar3 in the cooling curve of steel, contraction is arrested and an actual expansion takes place. In an ordinary 0·3 per cent. carbon steel the expansion between 690 deg. and 650 deg. C. is approximately equal to the amount of contraction between 790 deg. and 710 deg. C.; therefore in some castings of intricate design reversals of stress do not occur simultaneously in all parts. If such castings are left in the sand or on the floor, cooling at unequal rates in various parts, contraction will be taking place in some portions whilst in others expansion will occur, when adjacent members are in a plastic, or weak condition, resulting in "pulls" or "cracks" When such difficulties due to reversals of stress occur, modification in design by the engineer, so as more nearly to equalise the thicknesses in critical parts, affords one means of remedy. Another is by "chilling" or using one of the various methods, not altogether looked on with favour by the engineer, for making the thicker sections cool more rapidly where feasible, or, for any other reason, not undesirable.

Most steel founders have probably experienced cases where the use of "chills" has been followed by "cracks" in the casting, through the effect of using such chills not having been fully considered. An alternative method which might be adopted for some castings is to arrange for the cooling from a temperature above 770 deg. C. to take place in a preheated furnace, care being taken to "strip" the casting at a temperature sufficiently above this to enable it to be sealed up in the furnace before the temperature has fallen to the danger point. This method was adopted with success in the case of a casting for a ship of world-wide repute, having a heavy flange, or seating, about the middle of its length, after several unsuccessful attempts had been made to obtain a satisfactory casting by other means.

Cases occur where the engineer would be put to increased cost, or experience a difficulty, by omitting some portion objected to from the founder's standpoint, as, for example, in a cylinder or tube such as that shown in Figs. 1 and 2, having a heavy flange, XX', 2 ft. to 4 ft. from the mouth, and used only for bolting the cylinder on to its entablature, which present two difficulties to makers. One is to feed the square flange to ensure soundness; the other, which is possibly of more consequence, is to prevent pulling in the bore of the cylinder about the centre of the width of the flange (see "A"). In such cases probably no really serious objection could be raised to introducing in this heavy flange a frame, Fig. 3, previously cast in steel, to act as a "chill," thus equalising the rate of cooling and also insuring an absence of cavities in the surrounding metal. There would be little theoretical and probably no practical loss of strength, as unless the "chill" was of excessive thickness it would to a large degree be fused by the fluid steel.

In the case of important castings subjected to severe stresses, such as large gun mountings, &c., the fullest and most careful consideration should be given by the

* Paper read before the Iron and Steel Institute, May 7.

designer to the placing of heavy masses or sections of metal where adequate arrangements can be made for "feeding," as, in the absence of "feeding heads," the thinner surroundings sections will "draw" on such reservoirs of molten steel and result in unsoundness or "piping" in parts where it is of the utmost importance that a large factor of safety should be provided.

The making of a ship's stem—free from defects—might be instanced as an illustration of this important point as to the position and size of necessary "feeding heads," to ensure soundness, or, on the other hand, of alteration in design to obviate them—a problem which, owing to the great divergence in the types of castings required by users, is relatively more difficult of general solution (even if not of the same importance) than the recently much discussed question of producing sound ingots.

Such a casting usually has heavy brackets cast between the webs at the deck positions, large radii, advisedly, being usually formed, thus further increasing the relative mass at these places. There is little doubt that a more satisfactory casting would result, even if, superficially considered, such does not appear to be the case (owing to unsoundness or "piping" not being apparent on the surface), by breaking the continuity of the junction of the bracket with the section of the webs, particularly at the extreme forward point, as such recesses in the deck

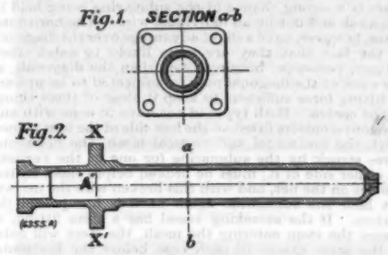
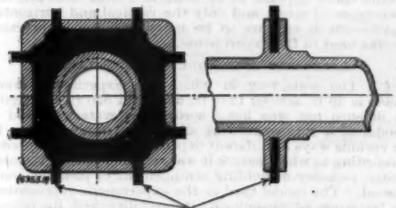
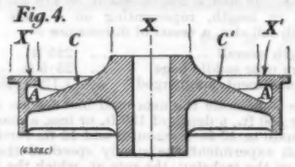


Fig.3. SECTION SHOWING METHOD OF FIXING SUGGESTED CHILL, PREHEATED BEFORE CASTING OPERATION.



The projections to be removed by Chipping.



brackets can safely be filled in later by electric welding and caulked to make perfectly watertight. If "feeding heads" are placed over these brackets the steel will remain fluid at these places after the general contour of the stem casting has solidified, thus tending to unsoundness, distortion, and troubles through contraction. Another point which should be borne in mind in connection with castings of this type is that during the period of cooling after casting the curved contour will tend to approximate to a straight line. Allowance should therefore be made by the pattern-maker for this tendency, particularly towards the two ends. When the annealing, or heat treatment, is carried out the contortion which would probably result if flames are allowed to impinge on the casting must be guarded against before the furnace is closed.

Modifications in design would be the more satisfactory expedient in some of the cases which come before the steel founder, parts being made separately where possible. This has sometimes the objection of increase in cost of machining, &c., but cheapness should not be the sole consideration in making such castings.

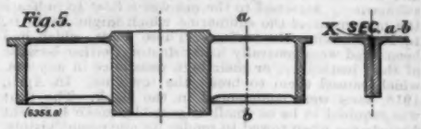
Castings of the type shown in Fig. 4 are sometimes asked for, with light ribs, A A, tied under internal flanges and also to a heavy plate or cone centre C C'. Such ribs naturally cool at a much quicker rate than the heavy disc portion and "feeding heads," X X', and are therefore in considerable tension, where the members join the periphery, when the plate portion and the centre boss have reached their maximum contraction.

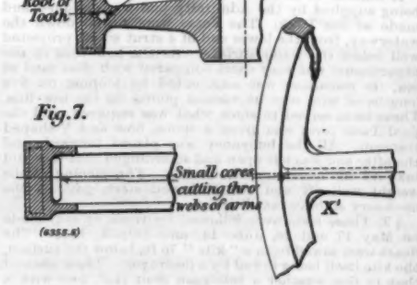
It is likewise a difficult matter to ensure perfectly satisfactory castings of such design as shown in Fig. 5. This shows a disc, or wheel, having spokes of heavy rectangular section on which is superimposed a plate of lighter section. "Drawing" or other defects, will probably appear in the plate over the centre of the spoke or rib (see X on section a b).

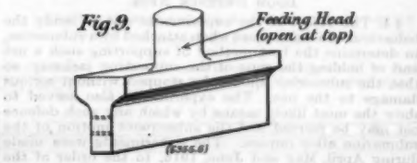
It must be admitted that a careful consideration by the management (and especially a joint discussion with all foremen responsible for seeing work through the different shops (of the problems to be faced in these and similar instances would conduce to the production of better castings; as it is sometimes seen, after a pattern is completed, that, if it had been made differently in some respect, to allow a modification in the method of making the mould, provision could have been more efficiently made for "feeding," and also for guarding against contraction and other troubles.

Such expedients as the insertion of tubing of small diameter and of considerable length rammed with sand, in lieu of cores where they are surrounded by large masses of steel—which cores would necessarily have to be made hard to stand and would become much more so through the contraction of the steel—would probably then be arranged for and much expense be saved in fettling and in the machine shop. It is well-known that bent or broken cores cause endless trouble when the casting reaches the drilling machine; in fact, in many instances it would be far cheaper to omit small bolt-hole cores altogether.

There is also a danger of small cores in one plane (say, for a number of bolt holes) causing vital cracks in large castings of heavy section, owing to contraction, the cores becoming very hard and offering great resistance whilst the steel is semi-plastic.







Steel-founders of repute have overcome the trouble of "honeycombing" and blowholes in castings. These in earlier days were considered almost unavoidable, in fact it has been stated in the past that the presence of blowholes might be taken as a "guarantee of quality in other respects"! Given steel properly melted and with suitable percentages of silicon and manganese, and care in making and drying moulds, little trouble is experienced in this respect; "piping," sand defects, &c., being far more frequently the cause of wasters.

The elimination of "honeycombing" has resulted in very largely increased productions of cast steel blanks for machine-cut gearing and similar castings, on which a large amount of machining is done; but, owing to the serious loss which would be incurred if defects developed, particularly at a late stage in the machining operation, it is very necessary that everything which can possibly be done to ensure perfection should be given earnest consideration. Arrangements should be made for the fluid steel to enter the mould at the bottom, and whenever possible a centripetal action, commonly termed "spinning," should be secured. Suitable risers and "feeders" should be provided where necessary, to ensure any "dirt" being brought up into the "heads." It is usually advisable to cast such articles quickly.

Castings of this kind are frequently produced without the slightest defect, provided the design be favourable. One cause of trouble has been due to the founder being asked to supply blanks of fairly large diameter with solid disc centres (Fig. 6), which have a pronounced tendency, in large diameters, to result in cavities being formed in the rim, practically in the position where the roots of the teeth are when these are "milled" out. This is due to the rim being of heavier section than the disc and therefore remaining fluid longer, and also, in cases where the change in section is not so great, to difficulty in arranging for adequate "feeding" at this place.

It is preferable to adopt "H" section arms, but it is then found expedient to break the continuity of the metal at the junction with the rim by placing a narrow core through the webs of the arms. If objection be made to such a method resulting in any weakening of the casting, this can easily be obviated by increasing the strength of the faces, or top and bottom flanges, of the arms by having larger radii between them and the rim (see X X', Fig. 7), which is preferable from the founder's standpoint as well.

The same problems are encountered in the production of smaller castings, weighing from a few ounces upwards, as supplied to motor and general engineering firms. The difficulties might be overcome in many instances if it were possible to arrange to submit suggested designs to some steel founder of good standing before hand. It is not intended, however, to convey the impression that all faults lie with the drawing office, as by careful attention and thought on the part of the foundry staff better articles could be produced by judicious use of chills, "feeders," &c. Further interchange of opinion would, however, undoubtedly lead to increased efficiency and obviate some of the troubles experienced by the engineer. To give one example only: Axle-box guides for locomotives, &c., are still made as shown in Fig. 8, A, which any user will understand generally results in "drawing" at X and X', in addition to causing extra work in the machine shop owing to the absence of tool clearances, instead of with a more gradual change in section and also of radii at the corners, as illustrated by Fig. 8, B, the more usual present design.

Innumerable examples might be adduced* affecting practically every type of steel casting made, but the desire at the moment is to persuade the engineer that exchange of views is of importance not only in respect of the production of castings without inherent weaknesses, but also in regard to the use of differing qualities of steel, or of special alloy steels, for various purposes.

The provision of suitable test bars, in the case of some forms of castings, is an important matter if sound pieces for tensile and bend tests are to be ensured. This should not be left to the discretion of the moulder, who is usually, in deciding where to place these, governed by considerations of convenience in respect to the moulding-box used for the job. The question is well worth consideration by the management, owing to the loss incurred if a satisfactory casting be rejected solely through inability to obtain test-pieces free from defects. In some cases, on cutting up a casting for test to represent others produced from the same cast of steel, or on breaking it under the tup for remelting, it has been found that the casting was perfectly sound, defects appearing in the test-pieces only. It is also highly advisable to provide for spare test-pieces, as cutting pieces from "rising heads," &c., often results in disappointment from causes such as segregation, &c.

Consideration should be given to such points as "feeding" the test bars, and whether the steel is able to flow freely through the part provided for tests; whether any dirt carried off the face of the mould, &c., may be trapped, and whether the test bar will be sound at the expense of unsoundness in the casting itself, or *vice versa*. For small castings it is advisable to treat the test bar as a separate casting but connected by a "spray" of sufficiently large sectional area to ensure that the test-piece is securely attached to the group of castings, or to the single casting, as the case may be, and also to give an adequate flow of steel into the test bar, on which a separate feeding head should be superimposed. A suitable design of test-piece for this purpose is shown in Fig. 9. The provision of test pieces from small castings may add very considerably to the cost of production, especially in cases where only a few are required from a pattern. This should be borne in mind when quoting, and the most favourable arrangements made with the inspecting engineer as to including a quantity from one cast of steel as well as from a single moulding box.

When moulds are made by machines, it will be found convenient to arrange the patterns on the plate, whenever possible so that one or more patterns can easily be removed and a test bar included in place in several of the moulds which will be put down for each cast. Special attention must necessarily be given to the method of fastening patterns to the plate to prevent any possible chance of displacement through the more frequent changing.

To ensure satisfactory test results it is necessary that the annealing or rather "heat treatment" (as the great majority of castings are now cast in mild steel and "annealing," *i.e.*, softening, to permit of the castings being readily machined, was principally required for crucible steel castings), should be carefully carried out. It is very advisable to have some means of recording temperatures, readings being taken in various positions in larger furnaces; at any rate until it is ascertained that something approaching a uniform heat is obtained in the particular type of furnace in use. The furnace attendant, if left to himself, often appears specially interested in recording flame temperatures rather than those of the castings under treatment. If personal attention is given, by some one holding a responsible position, to this matter of heat treatment, economies in working, as well as higher quality material, &c., may result as small modifications in furnace design, for instance slight alterations in the sizes and positions of admission ports, may be found advantageous.

There is no doubt that an experienced workman can judge temperatures to within a reasonable variation, at any rate under the atmospherical conditions he is accustomed to, but it will usually be found that the

* Hydraulic cylinders having square instead of rounded or spherical ends, for instance.

tendency is to estimate the temperature higher at night than in daylight, and the cost of a pyrometer is money well spent. The most satisfactory furnace is one in which the rate of cooling down at the critical temperature can be varied to some extent, as it is then possible to obtain small variations in the maximum stress where castings are made to stringent specifications.

Owing to the difficulty sometimes experienced in obtaining permission for material, which has given results, say, 2 tons to 3 tons over, or under, the maximum stress specified, to be retreated, it would appear that some engineers have not yet realised that the rate of cooling round the recalescence point of the steel governs the maximum stress, and that a substantial increase, or decrease, can be made by accelerating or lengthening the period of cooling through this range.

It is found in practice that heating to a temperature of about 950 deg. C. is advisable to ensure the "breaking down" of the cast crystalline structure, the final structure being, of course, coarser or finer according as the rate of cooling through the critical range is slow or rapid. This temperature is much higher than is theoretically necessary but experiments over a considerable period show the necessity for the higher temperature. The original crystallisation of a casting will, of course, be governed by the mass of metal and the rate of cooling after casting either in the mould or, if "knocked out," early after casting, on the foundry floor.

The length of time necessary thoroughly to "soak" castings and complete the "breaking down" throughout is a matter of judgment depending on size, thickess of metal, position the castings are loaded in the furnace, and probably several other considerations.

When dealing with large castings of heavy section it is advisable to pack them well up from the floor of the furnace. If this can possibly be done, pieces having heavy cores should be rough fettled before being placed in the furnace. The annealing will then be more efficiently and expeditiously carried out.

Generally, if arrangements are made which will admit of castings being cooled off quickly through the critical range without risk of distortion, setting up of stresses, &c., through currents of cold air impinging on one part of a casting, or other causes, an increase in the maximum stress without decrease in the elongation can be looked for and, owing to the closer structure, better results from bend and shock tests obtained.

Many cases have been noted where mild qualities of steel, as cast, have given practically the same maximum stress and elongation per cent. as after annealing, for instance a breaking strain of about 30 tons per square inch with 28 per cent. to 30 per cent. elongation in 2 in. Untreated samples fail, however, to give anything approaching satisfactory bend tests. It is possible that manufacturers of high quality castings may soon consider that some form of shock test might, by no means, be against their interests if lower grade material, less suitable for the purpose required, and supplied at a cheaper rate, be in this way eliminated from competition. The importance of the annealing or "heat treatment" of steel castings has been specially mentioned in papers read at various times before kindred societies by Mr. Harry Brearley, and a study of these is well worth the time so spent by anyone responsible for the production of steel castings, as are also papers which have recently been read on steel ingots by Messrs. Brearley, Kilby and others, the problems requiring solution being closely allied.

The aim of every maker should be to produce castings absolutely, not commercially, free from defects, and the engineer should be willing to give earnest consideration to any reasonable modifications which may be suggested by men of experience. By close co-operation, steel castings might be produced which could be used with the same confidence as is extended to forgings when it is borne in mind that practically the same structure in the steel can be obtained by correct heat treatment as by work done on the steel during the process of manufacture.

SWISS MACHINERY IN BRAZIL.—The Commercial Secretary to H.M. Embassy at Rio de Janeiro, in a recent despatch to the Department of Overseas Trade, transmits a copy of a letter which he has received from the Secretary, British Chamber of Commerce, of Sao Paulo (Brazil) with reference to the activities of the "Sociedad Commerciale Industrial Suissa no Brazil." The letter gives expression to the opinion that certain Swiss concerns are making considerable headway in the machinery business which used to be largely in the hands of German concerns, and it is believed that they quite possibly have relations with certain large German manufacturers. The letter further states that it is almost impossible to make a success of the machinery business unless a competent engineer, with possibly good mechanics under him, is employed by those charged with the disposal or handling of such material. In addition, stocks of the machinery must be kept as well as a reasonable quantity of spare parts. The Sociedad in question is represented by someone able to answer and discuss technical questions in five or six languages or prepare plans for alternative schemes covering installations for packing houses, electric railways, heavy Diesel engines, cotton, spinning and weaving mills, hydro-electric power plants, &c. British manufacturers should adopt the same principle; they might form a combination representing distinct lines of engineering which do not clash one with the other, and place this in charge of the large British merchant firms established at various points, provide them with properly paid and highly competent men to manage the engineering departments, and through the channels already opened by such merchants, make a definite bid for all engineering business which from time to time presents itself.

MODEL EXPERIMENTS IN CONNECTION WITH SUBMARINE WARFARE.*

By G. S. BAKER, O.B.E.

§ 1. DURING the four years 1915-18 a very large amount of research work of vital importance to the nation was conducted at the Tank. This work can be divided into five different sections—mine design and sweeping, torpedo firing, seaplane design, tests of standard ship forms, and submarine catching. A very brief account of the work under these different headings is given in the Tank Report for the year 1919, and by permission of the Lords Commissioners of the Admiralty a detailed account of one section of the work is now placed on record. This section deals with the efforts made to cope with the submarine menace by means of nets hung in such channels as were used by the enemy submarines. These nets were of two kinds, one intended merely to indicate the presence of submarines, the other to prevent a submarine from passing the net.

INDICATOR NETS.

§ 2. The problem brought to the Tank by the Submarine Attack Committee in connection with these nets was the design of a satisfactory float. The nets were light in construction, hung in strong steel wire frames, and intended to be ripped from the frame by a passing submarine. Attached to the net was a float to indicate the movement of the submarine which might be 50 ft. to 100 ft. below the surface. Those floats, which had been tried were generally unsatisfactory, either because of their instability, or their high resistance in any sea, which caused them to break the tow line. In April, 1915, tests were commenced in the Tank. The float was required to be as small as possible, make sufficient disturbance when towed to render its movement visible, to be directionally stable when towed from a submerged point up to at least 10 knots' speed, and to carry a weight of 23 lb. when at rest.

A number of floats were tested, all of full size, some being supplied by the Admiralty and five designed and made at the Tank. The floats were towed down the waterway, from the lower end of a strut which projected well below the water surface. As the tow wire in the experiments was very short compared with that used at sea, its resistance was augmented by looping on five lengths of wire rope at various points on the tow line. These tests served to show what was required, and the final Tank form was given a spoon bow and V-shaped transom. All the buoyancy was placed forward, and the after end was left open and so arranged that it would take all the necessary mechanism. The placing of the weight well aft and the V-shaped stern gave it the necessary stability at all speeds.

§ 3. These tests were followed by trials at sea, made on May 17 and 28, June 11, and July 2, 1915. The floats were towed from a "kite" 70 ft. below the surface, the kite itself being towed by a destroyer. These showed that in fine weather a toboggan float (*i.e.*, one with a flat bottom intended to plane on the water) with a rear fin, could be made quite stable, but gave little or no splash. In rough water they were liable in short seas to receive a blow square to the flat bottom and part the towing wire—all the floats of this type tested, behaved in this way. The Tank form towed well in both rough and smooth water at all speeds up to 14 knots, and gave a good splash at all moderate speeds.

BOOM DEFENCE NETS.

§ 4. The object of the experiments was to study the behaviour of a defence net when attacked by a submarine, to determine the best method of supporting such a net and of holding the ends of the supporting jackstay, so that the submarine should be stopped without serious damage to the net. The experiments also served to show the most likely means by which any such defence net may be pierced and the subsequent motion of the submarine after impact. The experiments were made during April, May and June, 1916, to the order of the Booms Trial Committee.

§ 5. *General Considerations.*—The advance of a submarine in any direction may be arrested by a net in one of three ways:—

(1) By retarding its movement without slewing it.

(2) By deliberately converting its translatory motion into rotary motion—upwards, downwards or sideways.

(3) By loading the submarine with such weights that it must go to the bottom.

These experiments deal only with methods (1) and (2).

Any of these ends has to be obtained by means which give security against the attack of such craft on the surface, and the means provided must withstand the thrust of the tide and heavy weather.

The nets must be supported on floats, and to withstand the tidal thrust and surface attacks these floats must also be connected by strong wires or jackstays, secured at or loaded at their ends. To keep the nets from being swept to the surface they should be slightly loaded. If the submarine is to be brought to the surface, the net must be strongly secured to the jackstays. If it is to be thrown to the bottom, it must be secured to the jackstay, preferably by parting strips, and strongly anchored at several points along its length. With a loose bottom and very deep water with not much tidal movement, the latter method would result in the submarine meeting the bottom with heavy trim by the bow, and it would probably remain embedded in the bottom. This method of defence is dealt with in § 21. For shallow channels, method (1) is the only practicable one. For deeper and more important waterways the net must be able to work by either method (1) or (2), according to how it is attacked. In both these cases the retarding force is brought to bear upon the submarine, through the net—by its weight and the force in the wires. This force in the wires is transmitted to the jackstays and is balanced by the force at their ends and the water resistance of the floats. The net experiments, therefore, were arranged to determine the strength required in the net wires, when the net was attacked in various ways, and the effect of holding the jackstays in a rigid, semi-rigid or entirely free manner.

§ 6. For the sake of low resistance the nets are of large mesh. So far as weight is concerned there is little to choose between a mesh with vertical and horizontal sides, and one with its diagonals vertical and horizontal. With the former net, the stem of the submarine must always meet one or two horizontal wires which will "belly out" under the impact and be supported mainly by the vertical wires to the jackstay. The number of vertical wires taking the load will depend upon the depth at which the net is attacked, but will be at least two. With the diagonal mesh, unless the length of the diagonal of the mesh is made less than the average depth of the stem of a submarine (which means a smaller mesh than in the other), there is some chance of the stem entering the mesh. This contingency must, however, be allowed for in any case, as it is a comparatively simple matter to arrange the submarine stem so that it will open out the mesh and evade the wires. In both cases, therefore, there is a strong chance of the submarine being held in the mesh and not by an individual wire. The horizontal wires, however, have a slight advantage over the diagonals in the fact that they are more likely to catch deck fittings, periscope, housings, &c., than the diagonals, as the apex of the diagonal may be subjected to an upward or lifting force sufficient to keep it clear of these things at the centre. Both types of net have to cope with any horizontal cutters fitted on the fore side of the bow planes. With the horizontal and vertical mesh, the horizontal wires struck by the submarine (or one of the verticals on either side of it) must be broken before these cutters can act on the net, and with this broken wire the net will not hold the submarine again until it has passed the cutters. If the attacking vessel has a stem fitting, to ensure the stem entering the mesh, the stem will enter to the same extent in each case before the horizontal cutters are strained against the wires, but the vertical wire is strained through a bigger angle over the cutter and is therefore more liable to part. There is, however, less strain on the clips with the vertical wires, and on the whole there appears to be little to choose between the two types of mesh, and only the vertical and horizontal mesh—which appears to be more common in practice—was used in the experiments.

APPARATUS AND MODE OF EXPERIMENT.

§ 7. The waterway in which the experiments were made is 30 ft. across, 12·5 ft. deep and 550 ft. in length. A defence net was hung across this waterway and a model of a submarine was allowed to impinge upon it in various ways at different depths and at various speeds. According to what feature it was required to test, the net, floats, jackstay or holding arrangement of jackstay were varied. The model used in the experiments represented in its mode of propulsion, its stability and its rolling (transverse and longitudinal) a modified "E" Class submarine. It had a displacement of 418 lb. and was 12·5 ft. in length, representing on a scale of one-eighteenth full size, a vessel of dimensions:—

Length overall	...	225 ft.
Beam over saddle bags	...	23·5 ft.
Displacement, submerged	...	1,120 tons.

On the same scale the nets used had a span of either 432 ft. or 450 ft., a depth of 120 ft. or less, a mesh either 12 ft. square or 15 ft. horizontal and 12 ft. vertical.

In each experiment the steady speed of the model, the load on the jackstay, the rate at which the jackstay paid out, the damage to the net, and the behaviour of the model were noted. The total number of experimental runs made against the nets is approximately 200, and no conclusion was formed unless it was found to be correct by one or more repeated trials.

§ 8. *The Model.*—This was built up of yellow pine planks and carefully shaped to lines provided by the Admiralty. The thickness of the shell varied from 1 in. to 1½ in., but the superstructure was solid. There were three hatchways to give access to various parts of the model. The model was propelled by twin screws in the same position and of about the same diameter as those in the ship. These were driven by two electric motors fitted in the after part of the model, and obtaining their power from 28 Edison cells amidships. Fig. A, opposite, shows the general arrangement. The propeller thrust bearings were fitted at the after end of the shafts. The couplings between the motors and shafts were loose, to allow for any want of alignment between the armature and the shaft, or for any slight warping of the model. The number of cells used could be varied from 14 to 28 in steps of two, the regulating switch being controlled from outside the model. Fully charged, the model had a submerged speed corresponding to 11·7 knots for ship. The minimum speed was found by experiment to be 4·7 knots for ship.

At the after end the model was fitted with strong vertical and horizontal metal fins, exactly the same in outline as the fins and rudders on the ship, but strongly secured to the model. No guards were fitted around the propellers. Bow planes were fitted, but these were not movable, being secured to the model so that their plane was parallel to the deck, or top of superstructure. A conning-tower carrying two periscope housings was fitted, and jumping wires were run from the latter, to the stem, aft to a point on the superstructure at about one-third of the length from the stern. Two jumping wires were also fitted from the forward outer corner of

* Paper read before the Institution of Naval Architects, March 24, 1920.

each plane to the stem—one horizontal, the other slanting down to the heel of the stem. The stem was covered with thin sheet brass to prevent the net wires cutting the wood.

The vertical fin at the after end was adjusted so that when the model was quite free, submerged, and propelling itself, it would follow a straight course for some distance. To bias it so that it would turn to port or starboard a small fin, 1 sq. in. in area, was fitted above the superstructure aft, and could be fixed in any angular position. Holding irons were fitted to the model so that it could be handled from the sides of the Tank.

FIG. A. GENERAL ARRANGEMENT OF MODEL (MIDSHIP AND AFTER HATCHES REMOVED).

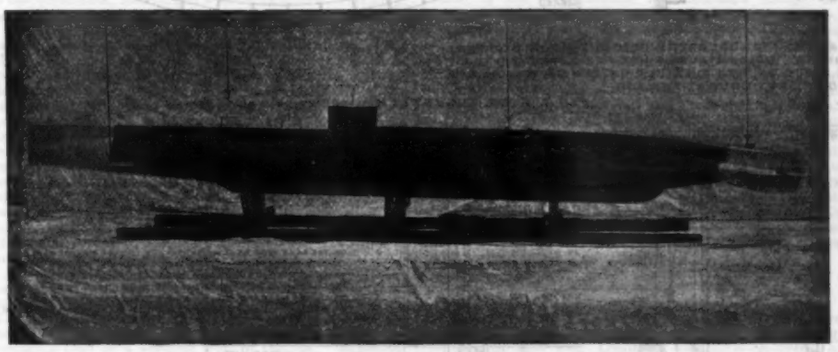


FIG. B. MODEL READY FOR EXPERIMENTS.

These were placed only in such position as made it impossible for the net wires to foul them. The complete model was given several coats of white lead paint and final coats of shellac varnish, each end being afterwards painted white to render its movements visible when submerged. The complete model is shown in Fig. B, above.

The model was ballasted so that its transverse metacentric height when submerged was to scale 0·2 in. for ship. Its transverse rolling period (from port to starboard and return) was equivalent to 2·01 seconds for ship. The longitudinal radius of gyration of the model, found by oscillating the model in air when suspended bifilarly, was one-third the half-length of vessel. This was somewhat less than was desirable,* but it was not possible to place the ballast nearer the ends of the model without rendering the internal mechanism inaccessible.

§ 9. *The Nets.*—The material of which the nets could be made was required to be fairly hard, comparatively weak for its diameter, capable of being held together at the corners of the mesh, and of maintaining its shape and size in the water. Eventually, after trials of various materials, a wire of suitable gauge was adopted. The net was brought to its correct weight in the later experiments by suspending weights at each corner of the mesh, in some of the earlier experiments by weights at the bottom of each vertical, and in the first trials was left uncorrected.

It was important that there should be no slipping of the wires at the corners of the mesh, and, to ensure this, single reef knots were formed in both horizontal and vertical wires at every corner. This caused some loss of strength in the wire, and the break usually occurred at the corner. The actual strength of the net was obtained after the experiments with it were complete, by breaking out three horizontal and three vertical wires and testing them. The figure taken as the breaking strength of any wire in any case, was the mean of these three tests. The variation in the results of these tensile tests was about 9 per cent. total between different nets and the wires in the same net. The wire used was ordinary trade wire and may have varied a little in diameter, but more probably the knot was made better in some cases than in others. Sinkers of the correct weight (to scale) were fitted at the bottoms of the verticals.

§ 10. *The Net Floats.*—These were made of solid pine when the originals they represented were of wood, and of thin brass plating when the originals were made of steel plating. The wooden ones were allowed to soak in the water and were then loaded down to an approximately correct water-line, when about one-quarter their volume was out of water. The models of the C and F floats (steel) were of about right weight as made.

The jackstays in the first experiments were made in short lengths fastened to eyes in the floats. This was found to weaken the jackstay too much, and in the later tests the jackstays were continuous across the whole section of net, with one turn on each eye in each float. The eyes holding these jackstays to the floats were in exactly the same position as in the full-size floats.

The upper ends of the vertical wires of the net were secured on the jackstays by knotting the wire over them, and were held from slipping by covering the knot and a short length of the jackstay with pitch. This hardened in the water and held quite well, and no slipping of this kind occurred in the experiments.

§ 11. *The Jackstays.*—These varied in number and strength with the type of floats tested. Where more than one jackstay were used, they were drawn together at each end about 1 ft. beyond the last float, and secured to a strong string, by means of which it was kept in tension.

§ 12. *Tension in the Jackstay and Recording Gear.*—The apparatus used in the majority of the experiments is shown in Fig. 1, below. A weight was suspended in a pipe on each side of the Tank, and the suspending string, after passing over a pulley, was wound round and secured at its end to the 2-in. wheels at U. A second wheel, 4 in. in diameter, was secured on the same spindle and the string attached to the jackstay was wound round and secured to this pulley. The tension in the jackstays at their ends was therefore one-half the tension in the strings supporting the weights. The actual tension in the weight string varied during each experiment according to the rate at which the jackstay was moving, and arrangements were made to measure the first part of this movement when the acceleration was likely to be appreciable.

A light carriage working on levelled rails was attached to the weight string (see Fig. 1). This carriage carried on its upper surface a sheet of cardboard. A dotter making 50 vibrations per second was arranged so that it just touched the cardboard when at the maximum amplitude of its oscillation. As the jackstay moved out and the weight lifted, the dotter recorded the distance travelled at every 1/50 second. This dotter was in the same electric circuit as a tuning fork with which it had been synchronised, and could be kept vibrating for any length of time.

§ 13. *Speed and Direction of Model.*—There were two possibilities of propelling and directing the model:—

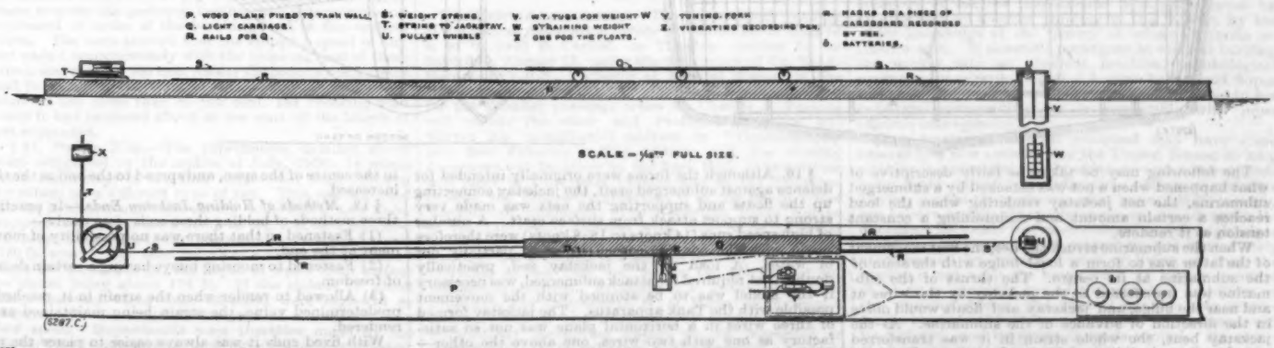
(1) To have it free throughout the experiment, controlling its motion by setting its fins and rudders before starting it.

(2) To hold it by the carriage which travels over the waterway, giving it bias in any direction, and releasing it some 10 ft. before reaching the net—the propellers working at the necessary rate for propulsion at this speed.

Both of these methods were tried. For (1) the model was started from a punt 70 ft. from the net, and the time taken to travel the last 35 ft. just before striking the net was noted. This start was necessary to allow the model to attain a reasonably uniform velocity, and a greater length would have been better, but even at this distance the point of impact was very uncertain, and only the first tests on the B net were made in this way.

In method (2) the model was held to the travelling carriage by two vertical struts, one gripping the model by a short piece of bar between the periscope housings, the other holding the horizontal stern fin in such a way as to allow the model to run out forward when the carriage stopped. The propellers were set in motion with the desired number of cells in circuit, the carriage moved towards the net at a predetermined speed, and the model was released from the forward grip when the stem was about 20 ft. from the net. The number of cells necessary for propulsion was determined by the earlier tests already mentioned and occasionally checked by running the model (free) under the travelling carriage. The model could be directed to any portion of the net by starting it with bias to port or starboard, or by immersing it to different depths on its struts. This method was adopted in all but the first two days' tests.

Fig. 1.


JACKSTAY MOVEMENT RECORDING APPARATUS
REFERENCE TABLE.
P. WOOD PLANK FIXED TO TANK WALL.
Q. LIGHT CARRIAGE.
R. RAILS FOR Q.
S. WEIGHT STRING.
T. STRING TO JACKSTAY.
U. PULLEY WHEELS
V. WT. TUBE FOR WEIGHT W
W. SYRAKING WEIGHT
X. ONE FOR THE FLOATS.
Y. TUNING FORK
Z. VIBRATING RECORDING PEN.
a. MARKS ON A PIECE OF CARDBOARD RECORDED BY PEN.
b. BATTERIES.
SCALE — 1/48TH FULL SIZE.
(5297.C.)

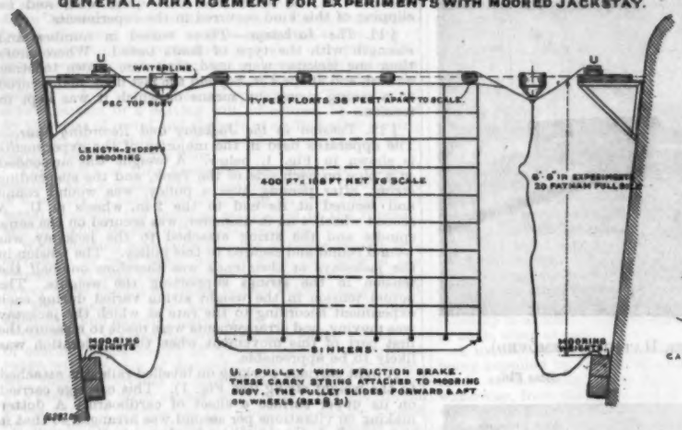
* The longitudinal radius of gyration of the ship assumed to be a solid of uniform density throughout its mass, is 0·42 of the half-length instead of 0·33 as above.

§ 14. *Experiments.*—These took three different directions, the study of (1) individual boom defence nets as fitted or proposed, (2) the methods of holding the jackstay and supporting the nets, so that the defence remained intact when attacked, (3) the determination of the necessary strength of the net wires and the general behaviour of net and submarine.

In each case the net was attacked on the surface at speeds possible with submarines when running on the surface; and at various depths below the surface, and in some cases the attack was made nearer one support than the other. In the general study of submarine, net and jackstay movement, a cinematograph was used and photographs were taken to illustrate the general behaviour.

Fig. 2.

GENERAL ARRANGEMENT FOR EXPERIMENTS WITH MOORED JACKSTAY.


WATERLINE
PEG TOP BUOY
LENGTH = 2 × DEPTH OF MOORING
TYPE E FLOATS 36 FEET APART TO SCALE.
400 FT. = 108 FT NET TO SCALE
6" 6" IN EXPERIMENTS 20 FATHAM PULL BACK
MOORING WEIGHTS
SINKERS
MOORING WEIGHTS
U. PULLEY WITH FRICTION BRAKE. THESE CARRY STRING ATTACHED TO MOORING BUOY. THE PULLEY SLIDES FORWARD & AFT ON WHEELS (§§ 8, 21)

(6287.)

§ 15. When the net was struck near the bottom, a horizontal wire usually held on the stem (or the stem entered a mesh). The angle of the bulge, which the stem formed in the net, would get smaller the farther the net advanced under the impulse of the submarine. But as the net was pushed out, the submarine was being pulled backwards and upwards by the "vertical" wires, and this upward pull in the net not only lifted the submarine to the surface, but being exerted at the extreme end of the ship trimmed it heavily by the stern. As the submarine lifted, the net settled more on the bow and there was less chance of it being pierced. Moreover, when the vessel had stopped advancing, the jackstay was still pulling it backwards, and in some cases the trim of the model increased very considerably during this backward movement.

If the model impinged on the net out of the perpendicular, the net action was very similar. The bulge in the net was necessarily not symmetrical, and there was a strong tendency as the submarine stopped advancing for it to slew round and foul the net with its propellers.

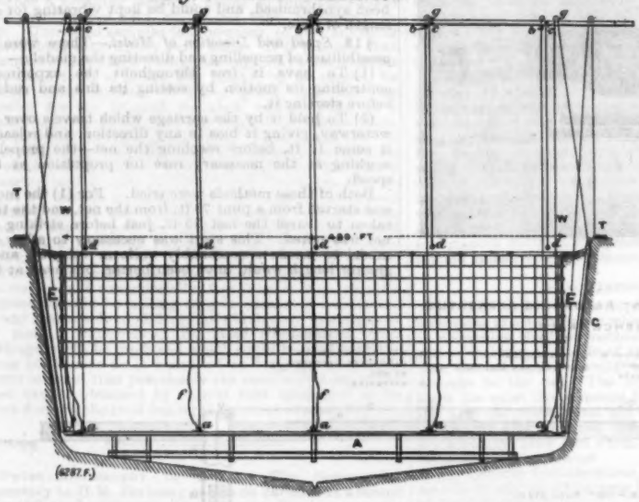
Fig. 3.

METHOD OF MEASURING RESISTANCE OF JACKSTAY & FLOATS (§17).

(6287.E.)

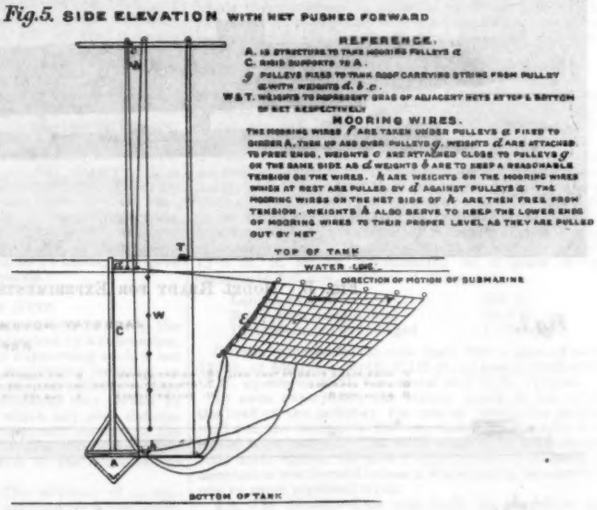
NET AS ARRANGED TO REPRESENT SLIDING MOORINGS (§ 21). THE ENDS OF THE HORIZONTALS OF NET ARE ATTACHED TO RINGS AND THESE SLIDE ON THE FLEXIBLE BATTENS E WHICH ARE SECURED TO THE NET ONLY AT THE TOP.

Fig. 4. FRONT ELEVATION.



(6287.F.)

Fig. 5. SIDE ELEVATION WITH NET PUSHED FORWARD


REFERENCE.
A. IS STRUCTURE TO TAKE MOORING PULLEYS d
C. RIGID SUPPORTS TO A.
g PULLEYS FIXED TO TANK ROOF CARRYING STRING FROM PULLEY d WITH WEIGHTS d. b. c.
W & T. WEIGHTS TO REPRESENT DRAG OF ADJACENT NETS AT TOP & BOTTOM OF NET RESPECTIVELY
MOORING WIRES.
THE MOORING WIRES f ARE TAKEN UNDER PULLEYS d FIXED TO GIRDER A, THEN UP AND OVER PULLEYS g. WEIGHTS d ARE ATTACHED TO FREE ENDS. WEIGHTS c ARE ATTACHED CLOSE TO PULLEYS g ON THE SAME SIDE AS d. WEIGHTS b ARE TO KEEP A REASONABLE TENSION ON THE WIRES. A ARE WEIGHTS ON THE MOORING WIRES WHICH AT REST ARE PULLED BY d AGAINST PULLEYS g. THE MOORING WIRES ON THE NET SIDE OF A ARE THEN FREE FROM TENSION. WEIGHTS A ALSO SERVE TO KEEP THE LOWER ENDS OF MOORING WIRES TO THEIR PROPER LEVEL AS THEY ARE PULLED OUT BY NET
TOP OF TANK
WATER LINE
DIRECTION OF MOTION OF SUBMARINE
BOTTOM OF TANK

The following may be taken as fairly descriptive of what happened when a net was attacked by a submerged submarine, the net jackstay rendering when the load reaches a certain amount and maintaining a constant tension as it renders.

When the submarine struck the net, the first movement of the latter was to form a local bulge with the stem of the submarine at its centre. The thrust of the submarine was transferred to the jackstay by the wires at and near the bulge, and jackstay and floats would move in the direction of advance of the submarine. As the jackstay bent, the whole strain in it was transferred to a few "verticals" (mainly) at the bulge, which also had to take the resistance of net and floats as these were dragged through the water. At low speeds and with perpendicular impact, no part of the submarine except the stem and its jumping wires touched the net, and the system would come to rest with the net on the bow of the submarine, and the thrust of the screws balanced by the drag of the wires. With impact at or about 24 ft. below the water surface, the same remark held good, unless the jackstay tension was very light, and not sufficient to balance the screw thrust. With heavy pulls in the jackstay the impact which was necessary to form a deep bulge was sometimes sufficient to break the net wires before the bulge could form. There was still the possibility in this case of the net holding the model if only a single wire had broken, by a wire fouling the fore end of the ballast keel, or by the double mesh jambing round the vessel, the submarine coming to the surface under the pull of the net, and the jackstay catching the top of the periscope housings, if the jumping wire was not taut.

§ 16. Although the forms were originally intended for defence against submerged craft, the jackstay connecting up the floats and supporting the nets was made very strong to support attack from surface craft. A number of high speed runs (14 knots to 18·8 knots) were therefore made with the conning-tower and stem partially out of water. A load on the jackstay end, practically double that required for attack submerged, was necessary if the model was to be stopped with the movement possible with the Tank apparatus. The jackstay formed of three wires in a horizontal plane was not so satisfactory as one with two wires, one above the other—in the former the strain was sometimes taken on the centre wire only (particularly if attacked with the stem just flush with the water when the bow wave tilted the floats up and threw the first wire clear of the stem), and this also had to support the net resistance and sometimes gave. These "surface" experiments, however, showed that the loading required was beyond what was practicable if the net was not to be pierced when attacked, so that the nets required very considerable strengthening to cope with all possible chances of submerged attack with such heavy jackstay loads. A far more satisfactory arrangement would have been a strong and heavily-loaded boom for surface attack quite separate from the nets and their jackstay, which could then have been arranged for submerged attack only.

The limitations of the stopping powers of the boom defence nets at a number of different ports were obtained in this way. These nets varied in depth from 24 ft. to 120 ft., but the results with all of them were very consistent as regards speed limitations and the difference in result of attacking close to the surface or at great depths. The experiments led to the detection of more or less serious defects in some cases, and to the general strengthening of all defence nets, the originals being too weak for their purpose.

§ 17. These nets were invariably fitted in practice across tidal waters, and one branch of the work was to determine what was the effect of tidal wash upon the jackstay and floats. For this purpose the jackstays and floats were towed up the Tank. The jackstay was allowed to sag a definite amount by increasing the length to somewhat more than the span. A skeleton diagram of the arrangement is shown in Fig. 3, below. The total pulls in the jackstays to maintain definite and different sags was obtained in this way. These pulls were always much greater for the types with wood floats than for those with steel floats, the excess varying from 30 per cent. to 80 per cent. This was partly due to the latter being smaller, and to their better shape and arrangement. This pull in a tidal stream was most serious in some cases, amounting in a 4-knot tide to several tons. It constituted a definite handicap on the types with wooden floats as the greater jackstay pull necessary with them lowered the "stopping speed" of the defence.

In most cases the jackstay consisted of several wires, and it was found that with any very definite sag, if these wires were in a horizontal plane the floats became unstable in tides of 3 knots to 4 knots, and turned turtle, tangling the whole system. This was due to the outer wire of the bend taking the major strain, and the floats were therefore held against the tide from their after end, and no rectilinear float will maintain this position for any length of time. The turning turtle always commenced in the centre of the span, and spread to the end as the tide increased.

§ 18. *Methods of Holding Jackstay Ends.*—In practice, three methods of holding these ends were used:—

(1) Fastened so that there was no possibility of movement at the end.

(2) Fastened to mooring buoys having a certain degree of freedom.

(3) Allowed to render when the strain in it reached a predetermined value, the strain being maintained as it rendered.

With fixed ends it was always easier to pierce the net than with a rendering jackstay, the drop in the piercing or stopping speed with impact at 24 ft. below surface on a 430-ft. span of net was roughly 25 per cent. This general effect of fixed ends was demonstrated in several experiments when the jackstay wire jambed as it was running out. Although the net had successfully held the submarine up to then and reduced its speed considerably, it would generally pierce the net.

Moored Ends.—The general arrangement of the jackstay and net is shown in Fig. 2, above. The length of the net was 400 ft., and it was supported on rectangular floats. The jackstays were secured by a pendant to the lower end of large peg-top buoys which were moored at a depth of 20 fathoms by a steel wire rope of 40 fathoms. To give the retarding effect of adjacent nets against any local movement, a second pendant was taken from each mooring buoy and wound round the pulley and carried on a small trolley of the Tank side. This trolley could move freely up the Tank with the buoy, and the pulley un-

wound against a friction brake adjusted so that the pull in the pendant was 7·8 tons. When the net was more or less over its moorings its stopping power was only a little short of what it gave with a rendering jackstay. But in the flood of the tide, net and buoys would be pushed forward, and in so far as the slack of the moorings was taken up in this way the net lost in power of resistance, and with all of it taken up behaved only slightly better than with fixed ends.

§ 19. *Rendering Jackstay.*—Most of the experiments were made with the jackstay ends carrying a definite weight. In this condition the maximum strain in the jackstay exceeded the value of the weight, and this excess strain increased in relative magnitude when the point of impact of the submarine was near the water surface. This excess existed for a short time, and in practice would have its counterpart in the static friction of the winch to which the jackstay was secured. With a constant load on the jackstay, it was always an advantage to keep the load as small as possible consistent with doing its work.

On completion of the tests with constant load on the jackstay, some further experiments were made with the load increasing as the jackstay ran out, but starting with a small initial value. Unless the model after impact with the net was allowed to advance beyond what was practicable in the experiments, the initial load could not be reduced much, without the necessity of a very large (and therefore dangerous) final load.

When the forward movement of the submarine had been destroyed the backward pull on the jackstay was always greater than it was with the constant load. This pull as a rule was exerted at and about the bows of the model and was sufficient to overcome the propeller thrust and push the model backward, *i.e.*, stern first for some distance. As it went astern, the trim it had received from the net as it was pulled up was greatly increased, and reached as high as 50 deg. in one or two cases, against about 30 deg. with a constant load on the jackstay. One other effect of this varying load on the jackstay was noticed. The two ends seldom rendered exactly the same amount, and as a result there was some difference between the pulls on the two sides of the bow of the submarine, resulting in a certain amount of slewing, *i.e.*, a greater tendency to turn broadside on to the net.

§ 20. The stresses in the net wires are determined by several factors, some of which depend on the nature of the blow. The stem of the submarine might enter a mesh or catch on a horizontal wire. In either case the push of the submarine was resisted by the water resistance of the net, and by the pulls in the verticals. When the net had bulged a little, the jackstay and floats began to move under the influence of the horizontal component of the forces in the "vertical" wires. This horizontal component was required to balance (1) the fore-and-aft component of the jackstay due to its endwise pull—which increased as it paid out; (2) the force necessary to promote movement or overcome the inertia of the floats—which in some cases weighed several tons each; (3) the force necessary to overcome the water resistance to movement of the floats.

With impact near the surface, all of these forces came into play almost at once, and in most cases were transmitted to the submarine through only two of the verticals. The sum total of these three forces on each side of the point of impact had therefore to be kept below the breaking load of a vertical wire of the net. Moreover, since the pull in a horizontal wire bent over the ship's stem at a sharp angle had to balance the pull in the critical vertical wires, as well as some of the net resistance, these wires required to be somewhat stronger than the verticals. All the nets were made in this way, the difference varying in different nets from 30 per cent. to 12 per cent. For these reasons the jackstay loading was determined and expressed in terms of the breaking load of the vertical wires. The tests showed that the stopping speed of any net varied approximately with the breaking load of these wires, and that for the best results the jackstay end strain had to be about one-third of this, increasing to a maximum of not more than 80 per cent. the breaking load when it had rendered about 40 per cent. of the length of net supported.

§ 21. *Paddle Nets.*—The experiments detailed above were completed by the middle of July, 1916—14 weeks from the receipt of the first order—and were followed by others on a different type of net. This was intended for use in almost non-tidal waters, to be laid in long lines, supported by small steel floats at the top, and attached by wires from their lower edge to sinkers spaced about 120 ft. apart. The total length of a mooring wire varied from 100 ft. to 200 ft., the depth of water from surface to sinker being about 174 ft. If the sinkers to which these mooring wires were attached were regarded as fixtures, the net could be defeated at a comparatively low speed. Experiments were therefore made by the Boom Trials Committee to determine the forces necessary, first to break out a sinker in different bottoms, and then to drag it over the bottom. In the later Tank experiments the lower ends of the moorings were allowed to move when these breaking-out loads had been reached, the load being arranged to drop quickly to that corresponding to a dragging sinker.

Only a comparatively short length of net could be used in the Tank, and it was necessary to represent in some way the effect of adjacent portions of net, mooring wires and sinkers. Adjacent sinkers would strain principally along the bottom, but the inertia and resistance of adjacent net would be felt on all the horizontal wires of the net.

The experimental apparatus as adopted is shown in Fig. 4, opposite. The net was of the same mesh as before, but the end verticals near the Tank walls were replaced by light flexible battens, and the horizontal wires were attached to rings which could slide up or down the batten. From the top end of the batten a string was taken to a pulley on the tank wall. A similar string was taken from the lower end of the batten to a pulley at the tank bottom, and thence to another on the roof. These strings were loaded in various ways to give the effect of the drag of adjacent nets, and the manner and time (relative to the movement of net) at which each came into play were also varied.

The pull in the mooring wires was regulated by taking the wires over pulleys on the tank bottom and thence over pulleys on the roof. These wires were loaded each by two weights *d* and *c*, the latter close up to the roof pulley, and, attached to each wire on the "net" side of the pulleys *a* on the tank bottom, was a weight *h*. Between *h* and the net the mooring wire was quite slack, but when the net had moved under the impact of the submarine and taken up all the slack of the mooring, if the tension reached the sum of weights *c* and *d* the sinker would commence to drag. When it had dragged one or two inches the weight *c* moved to the other side of the pulley and the tension in the mooring dropped to $(d - c)$. The weights $(d + c)$ and $(d - c)$ were arranged to give the breaking-out and dragging loads for the sinker used.

The diagram (Fig. 4) shows the movement of the net, the line of attack of submarine being represented by an arrow. The trim of the model produced by impact was never very great, the general result being to pull the model down more or less bodily. Occasionally the net would slew the model badly, owing to unequal movement of sinkers or to impact at an angle, and this slewing continued after advance had ceased, until the propellers fouled the net.

§ 22. With some adjustment of the relative strength of wires, this type of net was approximately equal in stopping power to that already described. If the sinkers in actual practice "grew into the bottom" they would act as fixed moorings and the stopping power would suffer. But the moorings could be arranged to give a quite good margin over the experimentally determined breaking out load.

§ 23. It will be easily understood that it is not possible to give the many detailed conclusions arrived at in the course of the experiments, as submarine attack on harbours, &c., is still to be reckoned with in the future. The experiments were witnessed on a number of occasions by various Admiralty and Port officials, and on June 14, 1916, a number of experiments were witnessed by the First Lord and Third Sea Lord of the Admiralty. The experiments were arranged in conjunction with Captain Learmouth, Captain Seymour and Commander Bircham, of the Boom Trials Committee. The details of the experiments were in part due to Commander Bircham who took charge of the cinematograph work, and Lieutenant Powell of the Cameronians. It was due to the energy and willingness of these and other members of the Tank staff, and particularly to the mechanics, that the first portion of this research work on defence nets was carried out in the short space of 14 weeks. The final report on the whole matter was sent off in 19 weeks from the receipt of the first order.

H.M. CRUISER EMERALD.—The launch took place recently, at the Armstrong Yard of Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne, of H.M.S. Emerald, a vessel of the light cruiser "E" Class, and an improvement and development of the "D" Class, of which class the Danae, Delhi and Dunedin were built at the Armstrong Naval Yard.

THE BRITISH ASSOCIATION.—The eighty-eighth meeting of the British Association for the Advancement of Science is to be held in Cardiff, on Tuesday, August 24, to Saturday, August 28, under the presidency of Dr. W. A. Herdman, F.R.S., Professor of Natural History in the University of Liverpool. The inaugural meeting is fixed for the Tuesday evening, when Sir Charles A. Parsons will vacate the chair and Professor Herdman will deliver his presidential address on "Oceanography and Sea Fisheries." The address and the evening discourses will be given in the Park Hall. The sections will meet in University College and in the Technical College, the Engineering Section G in the South Wales Institute of Engineers. The Reception Room will be in the City Hall, situated with other civic buildings in what used to be Cathays Park. It will again be a short meeting, the sectional proceedings opening on Tuesday morning, as last year, *i.e.*, before the delivery of the presidential address. Professor C. F. Jenkin will be the President, and Professor G. W. O. Howe, of Elmswood, Malden, Surrey, the Recorder, of Section G; communications concerning papers to be presented to Section G should be addressed to the Recorder. General inquiries about membership should be sent to the Assistant Secretary of the British Association, Burlington House, Piccadilly, W.1. The Chairman and Local Secretaries of the Executive Committees at Cardiff are the Lord Mayor, Councillor G. F. Forsdike, the Town Clerk, Mr. Cecil G. Brown, LL.B., and Mr. W. Evans Hoyle, D.Sc., the address being The City Hall. The terms of membership are now 1*l.* 10*s.* for annual members, entitled to receive the report, 1*l.* for members entitled either to attend or to receive the report, 1*l.* 5*s.* for transferable tickets without privileges, and 10*s.* for students. There will be evening discourses by Sir R. T. Glazebrook and Sir A. D. Hall, a reception by the Lord Mayor, and a Garden Party at Llanover by Lord Treowen; excursions will probably be arranged. Intending members should notify the London Office as soon as possible and write to the local secretaries for lists of hotels and lodgings.

PSYCHOLOGICAL *versus* "SCIENTIFIC" MANAGEMENT.

By CHARLES S. MYERS, M.D., Sc.D., F.R.S.

OF recent years efforts have been made to introduce from the United States into this country a system of industrial organisation known as "Scientific Management." These efforts have not been successful. The British workman is absolutely opposed to Scientific Management, and the cause of this attitude is not hard to find. It has arisen partly because a system which has met with some temporary success in one country has been introduced without modification into another, where the conditions of labour are obviously different. But a more fundamental cause of failure is that Scientific Management as originally advocated cannot be expected to be generally or permanently successful in any civilised land. At a recent meeting of electrical engineers in London, where a paper was read by an enthusiast in praise of Scientific Management, one speaker after another criticised the system adversely on the ground that it did not take sufficiently into account the human aspect of the problem. This criticism, coming from engineers of this country, is important, seeing that the father of the movement, F. W. Taylor, and many of its early advocates, have been engineers. They have not unnaturally tended to concentrate on the machinery of production, and consequently to regard the employee rather as an inanimate mechanism than as a human individual who has instinctive, emotional, and intellectual activities of his own, or as little more advanced than an animal.

After a few quotations from Taylor's book on "Scientific Management," including a statement that for successful pig-iron handling it is desirable that a man "shall be so stupid and phlegmatic that he more nearly resembles in his mental make-up the ox than any other type," the author remarks that he doubts very much "the real wisdom and appropriateness of adopting such an attitude before any worker in any occupation in any country," and further doubts "whether man is ever of the ox type, unless he is forced into it by his environment—by years of authority and by early suggestion."

Implicit immediate obedience, with suppression of independent thought and initintive, was the old military ideal; the army machine soon "broke" him who attempted to redress injustice or who sought to introduce progressive methods. If discipline, essential as it is in the world of labour, is to be reduced to this dead level, at which every spark of initintive and of self-expression is smothered, can we be surprised that the worker resists to his utmost that ideal of scientific management in accordance with which (to quote Taylor's words) "the managers assume . . . the burdens of gathering together all the traditional knowledge which in the past has been possessed by the workmen." Can it be supposed that mechanical obedience, coupled with high wages and diminished effort, afford adequate compensation for the loss of individual craftsmanship? "No worse mistake," says Taylor, "can be made than that of allowing an establishment to be looked upon as a training school, to be used mainly for the education of many of its employees." The author has no hesitation in retorting that no finer ideal, no aim more in consonance with the industrial spirit developing in this and other civilised countries, or more likely to check blind revolutionary tendencies, can be kept in view than "that of allowing an establishment to be looked upon as a training school . . . for the education of . . . its employees." If, as seems certain, the workers' secrets, and indeed all so-called trade secrets, are to be general property, like the scientific discoveries of professional workers, if, as seems inevitable, specialisation must ever increase, the boredom of narrow monotonous occupation must be safeguarded by a wider training of the worker, by his wider knowledge of the factory of which he forms so small a unit. If scientific management aims at turning the worker into an obedient machine, psychological management regards him as a human being, and hopes to invest him with as much knowledge and voice in his industrial surroundings as is compatible with most efficient management.

Such treatment as that criticised may have some success in a new country like the United States, so long as there is a plentiful supply of labour and a correspondingly rapid stream of immigration. High wages, says Taylor, is what the workmen want most. But does any one believe merely that high wages are an adequate inducement for vastly increased output, or that high wages without a vastly increased output are not immediately accompanied by increased cost of living so that the worker is not a bit the better off? A higher standard of living is certainly one of the principal ambitions of the working classes, but that is not the sole motive for his unrest, and his lessened output. He is also moved by jealousy, and suspicion towards capital. He envies the luxurious motor cars of the directors and shareholders for whom he works, and the rich furs, the extravagant dresses, the more varied amusements, the better facilities for education, enjoyed by their wives and children. He believes that capital has hitherto taken an excessive share of the profits of his work. He refuses point blank to accept Taylor's dictum that "all employees should bear in mind that each shop exists, first, last, and all the time, for the purpose of paying dividends to its owners." Is not this opinion alone sufficient to damn scientific management in the eyes of Labour in this country? In the United States, the first patrons of the movement employed it in order to fight trade unionism. In this country we recognise that the errors of trade unionism are to be removed rather by better mutual understanding and education. The old opposing camps

* Abstract of paper read before the Ceramic Society at Stoke-on-Trent, April 28, 1920.

of capitalist and worker can only be harmonised under the common ideal of what, for want of a better name, we call social service.

Two of the most important elements of scientific management are the task and the bonus. "Each man in the establishment," says Taylor, "high and low, should daily have a clearly defined task laid out before him. This task should . . . not be easy to accomplish." Regulations are laid down as to tasks being done in standard time, &c. The standard time is the quickest time in which a job can be done by a first-class man. The system of payment is so devised that the less expert or less industrious worker earns so little that he cannot afford to remain on the job. Taylor's ideal is to secure only first-class workers for scientific management, and to exact from them their maximum output. The workers' movements are timed by stop watches, openly if possible, or concealed in a sham note book if secret timing is unavoidable. Single factories in this country cannot hope to engage only first-class workers, as employers' federations and trade unions would equally seek to prevent it. The employers are not going to allow any one factory to monopolise the most capable workers. The more efficient man does not necessarily put forth greater effort than the inefficient to secure his higher and better output. Rightly or wrongly, many trade unions fear that payment by task, or even by results, means the overdriving of the average and the below-average worker, and the entry of a bad spirit of jealousy, rivalry, suspicion into the workshop. Rightly, perhaps, this attitude has been adopted in view of past experience; perhaps wrongly in view of a more harmonious and better organised future. It rests with the trade unions to see that none but sufficiently-qualified men are admitted to the full privileges of trade unionism. It rests with them to exclude grossly inefficient workers, just as the General Medical Council and the Incorporated Law Society excludes imperfectly trained doctors and lawyers—namely, by specified subjects and periods of instruction and by examination—thus preventing overcrowding.

Another well-recognised cause of trouble which besets the system of payment by results is the fear of rate cutting. A further cause of trouble which prevents each from doing his best is the fear that the weaker comrade will suffer and that with increasing output there will be increasing unemployment. Until guarantees can be offered that the rate, once set, will not be cut so long as the conditions of work remain unchanged, and that a man will not suffer when thrown out of employment through no fault of his own, no system of payment by results can hope to be really satisfactory.

To investigate and to suggest remedies for such fears and suspicions is the sphere of the applied psychologist, not of the engineer or other expert mechanician. The best can no more be got out of a worker who is suffering from mental discomfort than out of a worker who is suffering, from bodily discomfort. A specialist trained in the methods and principles of psychology—the science of the mind—and physiology—the science of the living body—is now fast becoming recognised as essential in all large industrial concerns. Those who realise the enormous contribution made by psychology during the war to the treatment of cases of nervous breakdown will readily appreciate the value of psychology in conditions of industrial unrest. Already in the United States, the crude blunders made by scientific management at its inception are being repaired by the engagement, in various factories and commercial houses of men trained in psychology and physiology. A National Institute of Psychology and Physiology, applied to industry and commerce, is now being established in this country. Its chief objects will be to train those who wish to take up this kind of work, to undertake special problems in any individual factory or firm when so invited, to establish and apply tests by which applicants for work can be selected according to the occupations for which they are mentally or bodily best fitted, to study and determine the most favourable conditions which tend to the mental and bodily health of the workers, and to harmony and co-operation between management and labour. Various trade unions and federations of employers are viewing the establishment of such an institute with favour, because they feel that, conducted by a body of trained scientific men, without profit, by scientific methods, without ulterior motives, they will from each side be able to appeal to it for an absolutely impartial solution of the various problems that confront them. The task of the Institute is great, and is of national importance, and only the promise of five or six thousand pounds a year more is needed for it to start on its career.

In the various inquiries initiated by or comprised in scientific management, the psychological factor must be taken into account, unless the inquiry is to be foredoomed to failure. Thus in the case of motion study and time study, the scientific management expert proceeds to divide up the job into a number of small, elementary movements and (quoting Taylor) to "study with a stop watch the time required to make each of these elementary movements, and then select the quickest way of doing each element of the work, and finally to "collect into one series the quickest and best movements." It is here assumed that the quickest movements are necessarily the best. But does it necessarily follow that the quickest way of doing a job is the best way of getting the best quality of output or the least amount of spoiled work? Does it necessarily follow that the quickest way of doing a job involves less fatigue for equal output? Secondly, it is proposed to combine together the quickest ways of doing each element of the work, and thus to reach a standard time and a standard method of carrying out the entire job. Each worker is to be trained in this standard method, and his payment is to be calculated on the assumption that the first-class man can be taught thus to perform the standard task according to standard method within standard time. It is assumed that "among the various methods . . . used in each element of each trade there is always one method . . . which is quicker and better than any of the rest." Certainly there is always one best method of work for every individual, but the best method of work for one person is not necessarily the best for another person. Even two apparently similar engines demand different handling to insure their best output. Are there not a variety (though a limited variety) of equally good first-class styles—as of hand-writing, golfing, violin playing—one or other of which different persons are best fitted to adopt according to their mental and bodily constitution? It is psychologically and physiologically unsound to force a man into one method of work, to train lads in the same mould, on the mistaken assumption that what is best for one is necessarily the best for all. Equally futile is it to take one element out of one man's performance, another element out of a second man's performance, another out of a third man's performance, because they each seem quick and good, and then, by combining them, to expect to reach the quickest and best composite whole. In the living mind and body, the whole is not the mere sum of its parts. It is the function of the psychologist, recognising the individual differences of equally good workers, to analyse their different methods, to investigate the mental and physical differences corresponding to those different methods, and to see that each worker is trained at the outset in the best method to which he is innately best fitted.

Gilbreth discovered that an expert bricklayer employed quite a different set of movements according as he is working at a fast or at a slow speed. He concluded that a beginner must be taught above all to work at a rapid speed, and to pay little or no attention at first to the quality of his work. To the psychologist this deduction must appear not only unwarranted, but probably untrue. Psychological investigations are clearly needed to determine the relation between speed of movements and quality of output which should be observed during training.

The recommendations and improvements suggested under scientific management require in every direction to be supplemented by psychological and physiological considerations. The human organism cannot be treated as if it were a mere machine, for the human worker is affected by accommodation on the one hand, and by fatigue and boredom on the other. The well-known Monday ill-effect, which has been shown to be independent of alcoholic or other dissipation over the week end, is only an exaggeration of what occurs at the start of every day's work. The operative has first to settle down to his work, to get into his stride, and to neglect external distractions. Towards the close of the morning's or the afternoon's work, the output is again bound to fall off. These variations in working capacity at different periods of the day have recently been shown to occur quite independently of any previous work; that is to say, they are in part due to a daily physiological rhythm—to hourly fluctuations in the daily wave of efficiency.

Where heavy physical work is being carried out, it is insufficient merely to study the most economical movements by which it can be performed. The amount of load which the worker can most efficiently lift, and the amount of time during which he should be under load require investigation. Taylor came to the conclusion "that a first-class man would do his biggest day's work with a shovel load of about 21 lb." In order to keep to a constant load the size of the shovel should vary according to the material to be handled. The total saving effected in the Bethlehem Steel Company's works by this and other improved organisation, when balanced against the increased cost of tool-room expenses, wages of extra foremen, time-study men, &c., amounted to between 15,000*l.* and 16,000*l.* per annum.

Regular rest periods during heavy manual labour are very important, but as regards both load and rest period much investigation is still required, and the numerous pitfalls which beset such inquiries can only be avoided by those already trained in psychological and physiological methods. A regular rest period has a very different effect from a chance pause owing to delay in the arrival of new materials. Its advantages were well illustrated during the war when two trench-digging sections competed against one another for the greatest length of trench that could be dug within a given time. The officer in command of one section allowed his men to dig as hard as they could for as long as they pleased, and then to rest. The officer commanding the rival section divided it into three groups, which he so arranged that two groups were always digging, while there was always a third group which relieved the other two alternately and was always resting. This latter section won easily. The same scheme has been successfully applied to bottle-making, three teams (each consisting of one man and two boys) being allocated to two machines. Their work was so arranged that one team was always resting for 20 minutes, while two teams were working for a 40 minutes' spell. The result was a very considerable increase in daily output.

By arranging materials at a convenient height, alike in brick-laying and in assembling, needless fatigue has been reduced, and output increased enormously.

Efficient lighting has been proved not only to increase output, but to reduce accidents and breakages. Dim twilight and blinding glare are equally objectionable, involving all the well-known consequences (mental and physical) of eye strain and fatigue. Overcrowding not only leads to needless accidents and breakages, but by perpetuating an atmosphere of discomfort, it inevitably induces a frame of mind in which the operatives cannot work their best. The same applies to avoidable dust and heat, and to deficient ventilation.

Vocational guidance and vocational selection are likely to be among the most valuable contributions of applied psychology to industry and commerce. Their objects are to advise the applicant as to the work for which he is innately best fitted, and to avoid, the disastrous effects of "round pegs" being placed in "square holes." Vocational guidance is applicable to the boy or girl on leaving school, and to the worker who is dissatisfied with his occupation and voluntarily asks for examination or advice. Vocational selection is applicable to all newcomers in any industrial or commercial concern. The basis of vocational guidance and selection is that for each person there is one most suitable occupation, and that in every occupation there are some who succeed better than others. Attempts have been and are still being made to determine a person's fitness for different occupations by the shape of his head or face, by the colour of his eyes or hair, by the texture of his skin, by the slope of his handwriting, &c. But such methods of procedure are devoid of scientific foundation, and no two people employing them will reach the same results. What psychology does is first to ascertain by careful observation and analysis the mental and bodily qualifications needed for a certain job, next to devise tests which are likely to reveal those qualifications, then to test those tests by applying them to known good or poor workers at that job, and then to select those tests, excellence in the performance of which correlates highly with known efficiency in the job, and to reject tests when such correlation is poor. The tests adopted may be weighted according to their importance, *i.e.*, according to their proved correlation. They are finally applied to subjects requiring vocational guidance or selection. Psychological tests have been successfully employed by our own Navy and Air Service, and on a huge scale by the United States Army during the war. They have been recently introduced into Columbia University, New York, as an alternative to the entrance examinations, the unsatisfactory nature of which is generally recognised. They have been employed for selecting girls who have the quickest reactions and the best powers of observation in the process of detecting defective bicycle balls; they have been devised for selecting the motor drivers of trams, who can speedily apprehend and act on a suddenly given situation; they have been employed for selecting telephone operators who have acute hearing, clear speech, good memory for figures, quick and accurate reactions to given signals; they have been applied also to assemblers, machinists, clerks, typewriters, &c. They have been used for selecting operatives who are best fitted to undergo a course of intensive training, with the result that their ranking, in accordance with the knowledge afforded by the tests, correlated very poorly with the original estimate of their capacity by the foreman who had been in charge of them, but correlated extremely highly with that foreman's estimate when he had become more intimately acquainted with the men during their subsequent course of instruction.

Scientific management has made a great contribution to the future improved organisation of industry and commerce. But without the co-operation and guidance of men trained in the principles of psychology and physiology, the merely mechanical innovations advocated by the engineering or other technical expert are fraught with great danger, and are liable to lead to disastrous results. Scientific management needs to be supervised and controlled by psychological management.

The expert trained in industrial psychology should be valuable as a member of the staff of any large factory or commercial house, not only for motion and time study, the distribution of hours of work and rest, and in selection study, but also as a referee in case of differences of opinion as regards human efficiency, *e.g.*, in regard to rate fixing, systems of payment, and for ascertaining and assuaging or suggesting remedies for the causes of suspicion and discontent.

IRON TRADES EMPLOYERS' INSURANCE ASSOCIATION, LIMITED.—The directors state that for the year ended December 31, 1919, the premium income amounted to 991,773*l.*; this, with 49,032*l.* dividends and interest on invested funds, made the total receipts 1,040,805*l.* The amount paid and provided in respect of compensation and incidental expenses during the same period amounted to 539,176*l.* There remained a balance on revenue account of 495,414*l.*, which the directors proposed to allocate as follows: Reserve Fund, 49,032*l.*; Staff Fund, 10,000*l.*; Investments Reserve Fund, 50,000*l.*; leaving a balance of 386,382*l.*, from which it was proposed to take a sufficient sum for a return of premium at the rate of 40 per cent. among the members of the association.

LARGE UNITS FOR NEW YORK POWER PLANT.—We are informed that the two 60-cycle turbine generators which will be installed in the new Hell Gate Station of the United Electric Light and Power Company, New York, will be of the tandem-compound type, each rated at 43,750 k.v.a., at 80 per cent. power factor, or 35,000 kw. They will be designed to carry peak loads of 40,000 kw. for short periods. These units, to be built by the Westinghouse Electric and Manufacturing Company, will be similar to the 60-cycle units installed in the north-west station of the Commonwealth Edison Company, with the exception that the newer units will have a rating of 43,750 k.v.a., as compared with 35,300 k.v.a. for the Chicago units. The generators will be designed for 13,200 volts and the units will run at 1,200 r.p.m. The turbines will be designed to operate at 220 lb. steam pressure, 200 deg. F. superheat and 29 in. vacuum. They will have reaction blading throughout. The high-pressure element of this type of machine is single-flow and the low-pressure element is double-flow.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

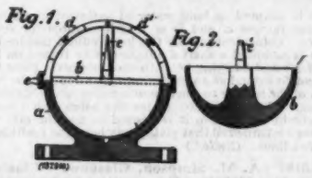
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

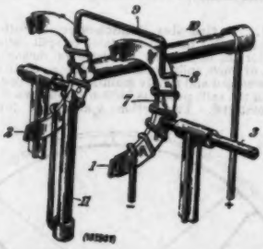
137,910. A. W. P. Tewkesbury, Weymouth. Indicating Angle of Flight. (4 *Figs.*) January 22, 1919.—The invention relates to an instrument fitted to an aeroplane for indicating in degrees by means of a vertical weighted pointer the angle at which an aeroplane is travelling in the air when passing through a fog or cloud, the degrees being marked on a frame. A semi-spherical-shaped frame *a* is mounted on a base for fixing the apparatus to an aeroplane. Inside the semispherical frame *a* is a semispherical weighted indicator *b* having a pointer *c*, so that the pointer *c* will point to a degree marked on the cross-bar *d*1



of the upper skeleton frame *d* affording indications in one plane only at one time. The spherical frame of the apparatus is formed in two parts having flanges *e* in order to be screwed together after the adjustment of the indicator *b*. The sides *d*1 of the upper frame *d* are divided out into degrees of angles, from zero up to 90 deg. Zero being the normal position of the indicator *b*, and pointer *c*. The semispherical weighted indicator *b* operates in the cup portion of the frame *a*, and is hollowed out. The upper spherical skeleton frame *d* is formed with cross bars having open spaces. (*Accepted February* 4, 1920.)

ELECTRICAL APPARATUS.

137,937. J. P. Yorke, Westminster, London. Magnetic Deflectors for Arcs. (1 *Fig.*) February 20, 1919.—The invention relates to a magnetic deflector or centraliser for use with an electric arc projection lamp, such as a search light. According to the invention, an arc-centraliser comprises a plurality of magnet poles disposed on each side of the arc so that a plurality of magnetic fields is produced across the arc tending to restore the arc when deflected from its normal position. The deflector comprises a pair of horseshoe electromagnets 1, 2, one magnet being mounted on a spindle 3 and the other magnet on a spindle 4.



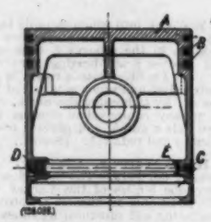
which spindles are supported in bearings. The spindle 3 is of sufficient length to extend to the outside of the lamp. The magnets 1, 2, are covered with heat-resisting and insulating covering 7, and the winding 8 comprises a few turns of bare copper. The winding is sufficiently heavy for the portion 9 to constitute a coupling-piece for the two magnets. The magnets are arranged one on each side of the arc formed between the positive carbon 10 and the negative carbon 11. The winding of the magnets is such that the north pole of one magnet is opposite to the south pole of the other magnet and the winding is connected in series with the arc. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

137,966. F. H. De Veulle, Birmingham. Carburettors. (4 *Figs.*) May 9, 1919.—The invention relates to float feed mechanism of carburettors, and it has for its object to provide

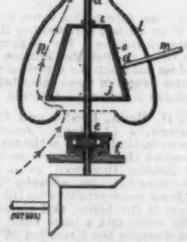
a method of preventing flooding due to vibration, which is very liable to occur with small high-speed engines. Accordingly, the float is a close fit in the float chamber and is adapted to make contact therewith only at points at the ends, which may be constituted either by projections on the ends of the float or by longitudinal ribs on the float chamber, which are engaged by the ends of the float. The float A comprises a piece of tube the ends of which are closed by caps B and the edges of these are provided with a number of projections C. The projections may be made in the operation of pressing or stamping the caps. Alternatively the walls of the float chamber may be provided with longitudinal ribs, the object in all cases being to guide the float at its ends, but to allow the free passage of fuel. By this means the float is prevented from vibrating in relation to the needle-valve seating and the flooding referred to is obviated. Furthermore, the clearance of the float in the float chamber can be very small without the float sticking, so that a dashpot action of the float in the chamber containing the fuel is obtained. (*Sealed.*)

138,028. Crossley Motors, Limited, Manchester, and T. D. Wishart, Stockport. Pistons. (2 *Figs.*) July 17, 1919.—The invention relates to vertically-reciprocating pistons of internal-combustion engines of the type in which a spring is applied in such a manner as to maintain the piston in constant contact with one side of the cylinder wall, whereby the tendency to knock against the walls of the cylinder is obviated. The invention is characterised by the use of an expanding spring ring inside the piston operating upon a scraper ring or shoe or slipper



through the medium of a plunger, pin or other suitable part. A is the vertically-reciprocating piston, B the ordinary piston rings, C a scraper ring, D the plunger and E the expanding coiled or split spring ring. The plunger D bears on the scraper ring C through the pressure of the spring ring E, and the resultant pressure forces the piston against the cylinder wall at the opposite side. By this means the piston is held in constant contact with one side of the vertical cylinder wall and is prevented from rocking. (*Sealed.*)

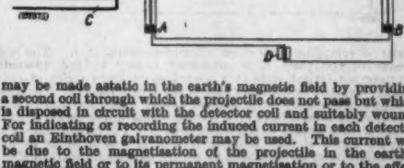
137,893. A. J. George, London. Carburettors. (1 *Fig.*) January 8, 1919.—The invention relates to carburettors applicable to the engines of motor cars and other vehicles or aeroplanes. The carburettor comprises a vertical spindle *a* having a ball race *c*, the said ball race being supported on a platform *f*. To the spindle *a* a cone *e* is fixed, by means of circular plates *i* and *j*, this said cone *e* being covered with felt *d*. The spindle *a* revolves in the bearing *b* and the ball race *c*, and is driven by means of a bevel gear. The bearing *b* is constructed with openings *g* in



order to allow the mixture to pass through the outlet pipe *n* to the engine. The mixing chamber *l* is a fixture, and is provided with an air inlet at its base, and with the petrol supply pipe *m* projecting through the mixing chamber *l* for supplying petrol on to the felt-covered cone as the said felt-covered cone revolves. A cover is fitted to the ball-race box in order to prevent any foreign matter entering therein. The travel of the air and mixture is indicated by arrows and broken lines *p*. (*Sealed.*)

GUNS AND EXPLOSIVES.

137,875. Sir R. T. Glazebrook, Teddington, F. E. Smith, Teddington, and D. W. Dye, Teddington. Measuring Velocity of Projectiles. (1 *Fig.*) October 2, 1918.—The invention relates to the measurement of the velocity of projectiles by electro-magnetic induction. The projectile is caused to pass through one or more coils and an indication or record is obtained of the current induced in the coils by the passage of the projectile. The effect may be intensified by creating a magnetic field through each coil by means of another coil disposed adjacent thereto through which a current is passed. The system



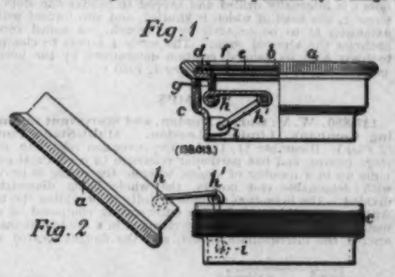
may be made astatic in the earth's magnetic field by providing a second coil through which the projectile does not pass but which is disposed in circuit with the detector coil and suitably wound. For indicating or recording the induced current in each detector coil an Einthoven galvanometer may be used. This current will be due to the magnetisation of the projectile in the earth's magnetic field or to its permanent magnetisation or to the effect of eddy currents. Two detector coils A and B, suitably spaced apart and arranged in parallel planes, are disposed in front of a gun C so that the projectile therefrom will pass through the coils in succession. The coils A and B are connected together in series and to galvanometer D. To intensify the effect two energising coils E and F are provided, and are respectively placed adjacent and parallel to the detector coils A and B. The coils E and F are connected to a battery G. (*Sealed.*)

MOTOR ROAD VEHICLES.

137,998. W. L. Coimer, Stowmarket, Suffolk. Pneumatic Tyres. (1 *Fig.*) May 21, 1919.—The invention relates to pneumatic tyres of the kind in which bands of material possessing the character of resisting the penetration of sharp objects liable to puncture the tyre, are located in the tread portion of the tyre with the object of rendering such tyres puncture proof. According to the invention, three endless bands or shields of vulcanised fibres are moulded within the tread portion of the outer cover of the tyre. *a* is the tread of the outer cover. *c* is the outermost band of vulcanised fibre and *d*, *e*, are the inner

bands. To retain the resiliency of the tyre as much as possible, the band *e* has, on its inner surface and midway between its two edges, a continuous rib *f* substantially semicircular in cross-section. The two bands *d*, *e*, have beads or thickenings *g*, *h*, substantially circular in cross-section along their inner edges in such a position as to co-act with the rib *f* when the tyre is pressed in, the said rib tending to enter between the beads *g*, *h*. The bands *c*, *d*, *e*, are of fibre, which is not too brittle as it must not crack should the tyre become entirely deflated. (*Sealed.*)

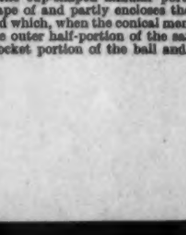
138,013. C. E. Milner, Birmingham, J. R. Taylor, Birmingham, and Benton and Stone, Limited, Birmingham. Filler Caps. (2 *Figs.*) June 14, 1919.—The invention relates to filler caps for fluid receptacles, such as petrol tanks for motor vehicles, and comprises the combination with a screwed cap, of a connecting shackle having one end attached to the inner or under side of the cap by a connection which is rotatable relatively to the cap, and serving to prevent complete disconnection of the cap when unscrewed. A hollow cap *a* provided with a glass disc *b* is internally screwed for connection with the externally screwed neck *c* which is secured to the filling aperture of the tank. The glass disc is held in position by a flange *d*



on the upper side of the cap and a ring *e* engaging with the interior threads of the cap. Between this ring and the glass is a freely rotatable ring *f* formed with a lug *g* to which is hingedly connected one end of a shackle, the latter consisting of a pair of hingedly connected links *h*, *h*1, one of which (*h*1) is hinged to lugs *i* pressed up from the interior of the filler neck, whilst the other (*h*) is attached to the lug *g*. The shackle is such that when the cap is unscrewed from the neck, the cap can be swung aside to an unobstructive position without complete disconnection from the neck. When attaching the cap to the neck the shackle in no way interferes with the screwing on of the cap, owing to the rotational connection between the cap and ring above-mentioned. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

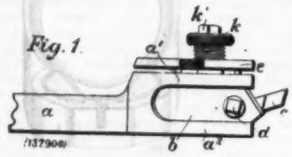
138,022. J. W. Tierney, Norwood. Connecting Rods. (2 *Figs.*) June 26, 1919.—The invention relates to connecting rods for pistons in which a ball and socket joint is employed as for example, in certain types of pneumatic drilling machines. According to the invention, the ball portion of the said joint is formed in one with or suitably attached to the connecting rod, and the socket portion of the said joint consists of two separate parts, one part being in the form of a cup integral with the piston, and the other part also in the form of a cup being integral with a comparatively thin conical detachable member possessing

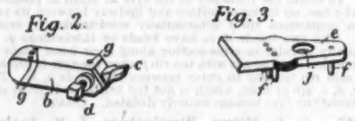


a certain amount of resiliency. *a*1 is the ball of the connecting rod, which fits and rests in the cup-shaped recess *b*1 which is contained in an inwardly-projecting boss *b* formed on the wall *c*1 of the piston, and which encloses the outer half-portion of the ball *a*1. *d* is the conical member which comprises at its inner or smaller end the cup-shaped annular portion *d*1, which conforms to the shape of and partly encloses the inner half-portion of the ball *a*1, and which, when the conical member *d* is in position, bears against the outer half-portion of the said ball *a*1, and thus completes the socket portion of the ball and socket joint. The

remaining portion d^2 of the conical member is integral with the cup-shaped annular portion d^1 and extends outwardly therefrom in the form of a uniformly-tapering cone, the outer end of the said portion d^2 having a diameter equal to the internal diameter of the piston and bearing against a circular flange d^3 provided on the wall of the piston. The conical member d is split along the length of its tapering portion d^2, so as to form a segmental opening e for the purpose of facilitating its insertion and removal. (*Accepted February 4, 1920.*)

137,900. A. H. Wineberg, Birmingham. Tool Holders (5 *Figs.*) January 17, 1919.—The invention relates to tool holders for machine tools, and it has for its purpose to permit of the tool being removed from the machine and afterwards replaced in the exact position as before without necessitating any process of resetting. According to the invention, a tool holder has a bifurcated tool post between the bifurcations of which a tool-box is adapted to be assembled, in combination with an indexing plate adapted to be located externally of the bifurcated part of the tool post and having provision thereon for adjusting the position of the tool-box with tool in one or other of several different accurately-defined positions in relation to the tool post. The tool post a is provided with a bifurcated head between the bifurcations a^1, a^2, of which the tool-box b is adapted to be secured. The tool-box b is of rectangular section, and its upper

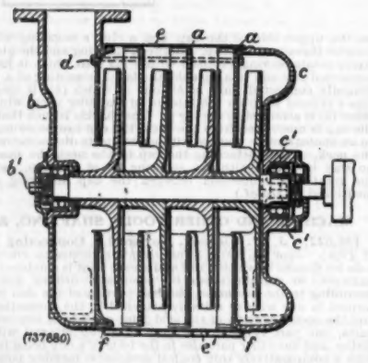




or lower surfaces are adapted to coincide with the internal flat surfaces of the bifurcations. The tool-box has formed in it a square hole in which the tool e is adapted to be secured by a clamping screw d. The tool-box is located within the tool post a by an indexing device. This comprises a plate e located externally of the bifurcated part of the tool post a and having projections f to pass through perforations in the bifurcation a^1 and engage with blind holes g in the tool-box b. A boss i is provided upon the outer face of the perforated bifurcation a^1; this boss passes through a perforation j in the plate e. Said boss i is internally drilled and tapped to receive the stem of a screw k, the head of which is knurled, and also formed with an extension k^1 to be engaged by a wrench. A coiled spring l encircles the screwed stem. The screw k serves to clamp the tool-box b in its located position determined by the indexing projections f. (*Accepted February 4, 1920.*)

PUMPS.

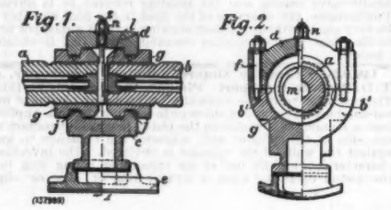
137,880. W. M. Gurry, London, and Sturtevant Engineering Company, Limited, London. Multi-Stage Pumps. (2 *Figs.*) December 11, 1918.—The invention relates to multi-stage pumps, and has particular reference to centrifugal pumps built up in a number of stages, wherein the casing is provided with detachable end covers, the whole being diametrically divided. The invention consists broadly in providing the pump with a removable and flexible outer casing composed of sheet metal adapted to be removably clamped in a fluid-tight manner around the intermediate stages, and the flanges located at or



around the end stages, such casing being constructed in one piece. The pump comprises a plurality of intermediate stages a and two cast end covers b and c which are held together by transverse bolts d. A sheet metal cover e is wrapped around the exterior peripheries of the sections a, and around flanges f formed on the covers b and c and end stages, the opposing edges of which metal cover is flanged as at e^1, and secured together by bolts. The covers b and c are diametrically divided, the meeting edges being formed with flanges b^1 and c^1, which are secured together by studs or bolts in the usual manner. (*Sealed.*)

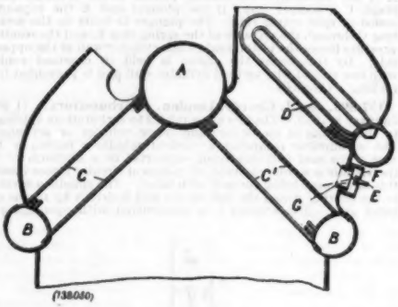
STEAM ENGINES, PRODUCERS, HOLDERS, &c.

137,889. Lilleshall Company, Limited, Oakengates, Shropshire, and J. L. Ewan, Wellington, Shropshire. Couplings. (2 *Figs.*) May 10, 1919.—The invention relates to couplings for connecting together rods such as the piston rods of engines, having each rod end encircled by a member which may be screwed in relation to the rod, and in which the respective members are embraced by a sectional coupling member. According to the invention, in this type of coupling the members which encircle the rods are of a sectional character. a and b are the piston rods to be coupled. c is the main casting of the coupling which is attached to the slipper c^1. d is the cap of the coupling c, which is attached to the latter by studs f and keys. The exterior portion of the coupling grips the piston rods a and b through the medium of two nuts g. These nuts are screwed to suit the screw threads cut on the piston rod ends, and are divided into halves along the line b^1-b^1, clearance being left so that the threads in the nuts g grip the threads in the piston-rod ends firmly, when the cap d is tightened down, and prevent any movement longitudinally between the rods and the nuts and prevent the rods from turning in the nuts. The nuts are attached firmly to the main body of the coupling c and d by



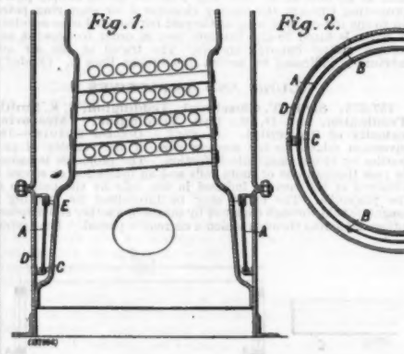
means of taper grooves j, into which suitable tapered projections on the portions c and d fit. These projections are so made that they cannot bottom in the grooves j, thus ensuring that the projections and grooves j are bearing hard on their tapered sides. A taper plate l is fitted into a recess in the end of piston rod b, and a wedge plate and screw m is placed between the ends of the piston rods. By tightening the nut m, these two wedges, l and m take up any compressive stresses which may exist between the two rods a and b, and prevent reversal of stress in the threads of nuts g and rods a, b. (*Sealed.*)

138,050. H. E. Yarrow, Glasgow. Superheaters. (1 *Fig.*) September 30, 1919.—The invention relates to superheaters of water-tube boilers of the Yarrow type. According to the invention, additional oil burners are provided in the space between the generating and superheating tubes. A is the steam and water drum, B are the water drums, C1, C2 are nests of



generating tubes; the superheater tubes are shown at D. E is an oil sprayer, F an air-box surrounding the sprayer, G an air distributor for the oil sprayer. The oil burner is inclined to the direction of the tubes so that the intense heat of combustion of the oil flame does not reach the superheater tubes and there is, consequently, little danger of these tubes being overheated when the flow of the steam is reduced. (*Sealed.*)

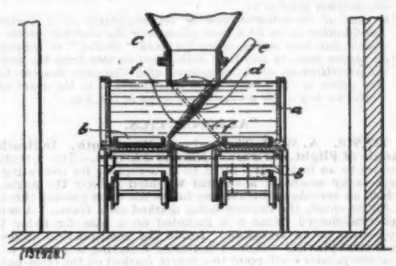
137,894. C. H. Benn, Leeds, and C. L. Benn, Leeds. Steam Generators. (3 *Figs.*) January 10, 1919.—The invention relates to vertical boilers of the type in which a division plate is fitted around the fire-box or flue concentric therewith, and at a short distance therefrom, so as to form an annular water space between the two, whereby the film of water so provided is rendered more sensitive to the heat than the bulk of water contained in the boiler, and consequently an effective circulation of the water and a more rapid generation of steam is produced, and whereby the formation of scale or incrustation is prevented or minimised. According to the invention, the division plate A is divided lengthwise into sections of convenient



size, overlapping each other circumferentially at B. The lower edge of the plate A is supported loosely by the upwardly-projecting forked ends of a spaced-apart lower series of radial lugs C welded to the inner side of the boiler shell D. The upper edge is secured by being pressed loosely under the downwardly-projecting forked ends of a corresponding upper series of radial lugs E, also welded to the boiler shell D. The forked ends of the upper series of lugs E are extended in length so as to have sufficient internal clearance to permit of a slight vertical sliding movement of the plate A between the upper and lower series of lugs E and C, this arrangement enabling the plate to be firmly secured in position for use and to be readily inserted and removed. (*Sealed.*)

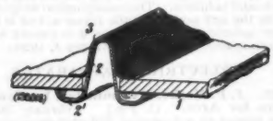
MISCELLANEOUS.

137,928. E. W. Robey, London. Conveyors. (3 *Figs.*) February 8, 1919.—In cases where it is desirable to exclude air from a hopper from which material is discharged on to a conveyor, the latter is sometimes contained in a water trough, the water in which seals the discharge opening of the hopper or the like. According to the invention, the conveyor in the trough is duplicated, the two conveyors being so placed relatively to the hopper that the discharge may be received by either. A trough a has tracks for two conveyors b at a suitable distance apart. The conveyors are of the endless chain type, travelling up inclines at the ends of the trough and returning beneath the latter. The



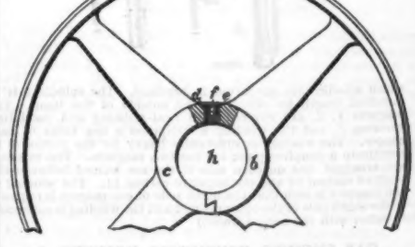
trough is adapted to hold water of sufficient depth to seal the discharge hopper c, and is of length suitable for several such hoppers. Coincidently with the longitudinal middle line of the trough is mounted a shaft d adapted to be turned on its axis by the lever e and carrying beneath each hopper a plate f of length sufficient to extend at an incline from one edge of the rectangular mouth of the hopper to the opposite conveyor, as indicated in the drawing. Thus the plate guides the ashes and clinker to the conveyor in use; when it is desired to use the other conveyor the lever e is turned so that plate f may have the position indicated in dotted lines. (*Sealed.*)

138,018. A. M. Simpson, Glasgow. Glazing Roofs. (1 *Fig.*) June 23, 1919.—This invention relates to glazing roofs, and has for an object to provide a construction whereby there is obtained a watertight joint without the use of putty or lead. The invention consists in the employment of astragals of sheet metal, shaped in section as an inverted U, with flanges forming gutters and capped by a strip of fabric secured to the astragal



and to the glass by adhesive, for example, white lead paint. 1, 1 denote the panes and 2 the intermediate astragal which is shaped in section as an inverted U with flanges 2^1. 3 is a strip of fabric extending longitudinally of the astragal, such strip being secured to the astragal and to the panes by means of adhesive, and rendered waterproof. If the adhesive employed be white lead paint, the paint serves as the waterproofing medium. (*Sealed.*)

137,487. T. Crossley, Manchester. Pulleys. (4 *Figs.*) July 8, 1919.—The invention relates to split collars and pulleys and has for its object the provision of means for connecting the parts of such split collars or pulleys, so that they can be readily assembled and rigidly maintained in an operative position. The boss of the split pulley is built up from two sections of metal or other material. The sections b and c are dovetailed with a



groove or dowel across their centre. These sections are bored and tapped at the centre of the dovetailed joint d and e and a set screw f is inserted to bind or lock the two sections together. The set screw engages with the screw thread cut in both sections. The set screw can be of such length that it will bear against the shaft h and frictionally hold the collar or boss b—c in position, or the shaft can be drilled and tapped to receive and engage the set screw. (*Accepted January 21, 1920.*)

BRITISH ORDERS TO HOLLAND.—It is reported in Brussels, says *The Iron Age*, New York, that English automobile builders have given orders for small steel castings to works in Holland. One must remember that it is not far by canal from Holland to the German frontier, and certain Dutch commission houses are in reality nothing more than exporters for concerns in Westphalia. There are several small foundries in the region of Zutphen, which could perhaps undertake this kind of work, but prices quoted in Dutch florins exceed by 30 per cent. the prices which the Belgian foundries would name in francs in Belgium if they had the coke, and if the receipts of all materials were less irregular than they are to-day.